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NOV 73 R F COLINGSWORTH, B J GUDMUNDSON DACW37-73-C-0059

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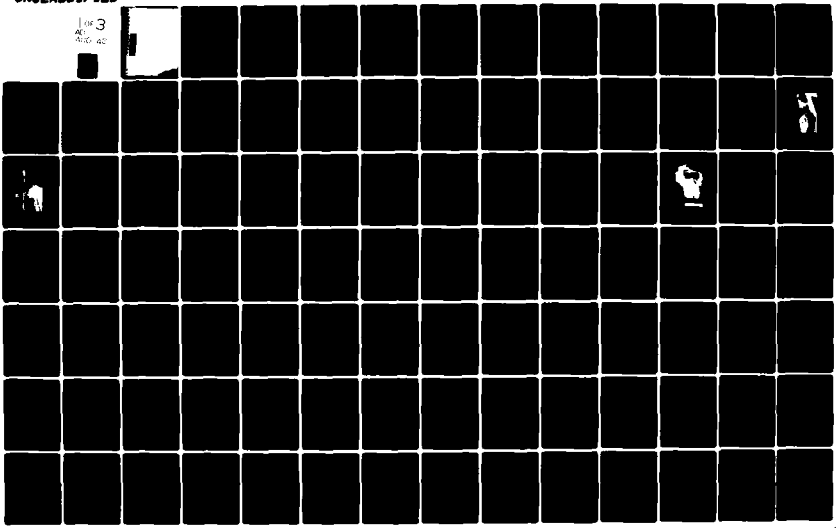

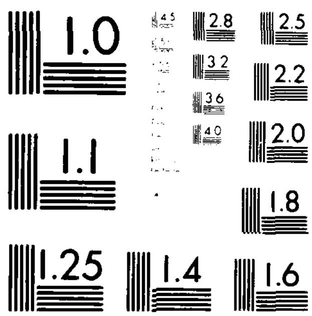

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The overall objectives of this report are to assess the impacts of Corps of Engineers' activities on the St. Croix River from Stillwater, Minnesota, downstream to its mouth. The report includes an analysis of natural and socioeconomic systems. The natural systems include terrestrial and aquatic plant and animal life, geology and water quality. This includes habitats of rare and endangered species. Socioeconomic systems include industrial activities, recreation, and cultural considerations, including archaeological and historic sites.

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FINAL REPORT

ENVIRONMENTAL IMPACT ASSESSMENT STUDY

ST. CROIX RIVER POOL

of the Northern Section of the
UPPER MISSISSIPPI RIVER

for the

ST. PAUL DISTRICT CORPS OF ENGINEERS
Under Contract No. DACW37-73-C-0059

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November 1973

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FOREWORD

Purpose of the Environmental Studies

The National Environmental Policy Act of 1969 directs that all agencies of the Federal Government "include in every report on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment, a detailed statement . . . on the environmental impact of the proposed action." The Act deals only with proposed actions. However, in keeping with the spirit of the Act, the U.S. Army Corps of Engineers has developed its own policy that requires such reports on projects it has completed and for which continuing operational and maintenance support are required.

In keeping with its policy, on January 15, 1973, the St. Paul District of the U.S. Army Corps of Engineers contracted with the North Star Research Institutte to prepare a report assessing the environmental impact of the Corps of Engineers operations and maintenance activities on the Mississippi River from the head of navigation in Minneapolis, Minnesota, to Guttenberg, Iowa. Included also are the Minnesota and St. Croix Rivers from the heads of navigation at Shakopee and Stillwater, Minnesota, respectively, to the Mississippi River. This portion of the Mississippi River basin will be subsequently termed the "Northern Section" of the Upper Mississippi River, the "study area", or "the St. Paul District".

The Corps of Engineers has been active in the Northern Section since the 1820's, when they first removed brush and snags from the river to permit navigation as far north as Fort Snelling. Later, in the 1870's, further improvements were made primarily through construction of wing dams, to deepen and maintain the channel. Presently, the river in the study area consists of a series of pools which were created by the construction of navigation locks and dams in the 1930's.

The purpose of the environmental impact study is to assess the impacts, both positive and negative, of the construction and operation and maintenance of the Corps' nine-foot channel project on the Northern Section. The operations and maintenance include operations of facilities (locks and dams) and navigation channel maintenance (dredging and "snagging"). Actually, the impacts on the environment of the Corps' pre-nine-foot-channel operations are also being sought, but most of the information will concern the impacts of the present navigation system.

The studies are designed to identify the impacts and to assess their effects on both the natural and social environment. Such impacts may include effects of river transportation on the area economy, effects of creation of the pools on recreational activities and wildlife habitat, effects of dredge spoil disposal on the natural ecosystem and on recreation, and many others. As a result of identification and assessment of the impacts, it will be possible to suggest ways of operating the facilities and maintaining the navigation and recreation system to amplify the positive and minimize the negative results of the Corps' activities. The study will provide a comprehensive basis for the St. Paul District to prepare an environmental impact statement consistent with the National Environmental Policy Act of 1969 and the policy of the U.S. Army Corps of Engineers.

Scope of Current Report

The present report covers the complete study program, from January 15, 1973, through November 1973. It was preceded by a Phase II interim report, which was completed July 1, 1973. The new report contains both historical information, and information and data collected in the field from activities such as water quality investigations and sampling of riverbank vegetation.

Research Approach

Three aspects of the research approach used in the study deserve clarification: (1) the benchmark point in time, (2) data collection and analysis of the natural systems, and (3) data collection and analysis on the socioeconomic activities.

Benchmark Time Point

In order to analyze the impact of the Corps' nine-foot channel project in the Northern Section of the Upper Mississippi River, it is necessary to select a point in time that can serve as a benchmark. This benchmark is the time activities related to the nine-foot channel were initiated. Because the Lock and Dam 3 raised the water surface of the St. Croix River and was completed in 1938, the preconstruction benchmark was taken as 1938. Wingdams were built and other Corps activities took place prior to 1938. These are discussed as preproject activities. The pre-project environmental data were obtained from available reports and from a variety of other sources cited at the end of each section.

Analysis of the Natural Systems

The impacts of Corps activity on the natural environment for a given pool were determined by the individual investigator responsible for that particular pool. The Northern Section of the Upper Mississippi River was subdivided into fourteen distinct segments for purposes of study of the natural environment: Pools 1 through 10, Pool 5A (lying between Pools 5 and 6), the Upper and Lower St. Anthony Falls (SAF), Pools (a single report covers both pools), the Minnesota River and the St. Croix River. A segment was assigned to an investigator on the natural sciences team, as listed on the following page.

Number of River Pools and Miles Involved		Navigation Pools	Chief Investigator	Organization
5	92.4	Upper and Lower SAF Pools, Pool 1, Pool 2, Minnesota River, St. Croix River	Roscoe Colingsworth	North Star Reesearch Institute, Minneapolis, Minnesota
1	18.3	Pool 3	Edward Miller	St. Mary's College, Winona, Minnesota
4	82.6	Pools 4, 5, 5A and 6	Calvin Fremling	Winona State College, Winona, Minnesota
2	35.1	Pools 7 and 8	Thomas Claflin	University of Wisconsin, LaCrosse, Wisconsin
1	31.3	Pool 9	James Eckblad	Luther College, Decorah, Iowa
1	32.8	Pool 10	Edward Cawley	Loras College, Dubuque, Iowa

Because different problems arise in different segments of the Mississippi River, each investigating team used its own judgment in conducting its studies. However, North Star--in conjunction with the investigators cited above--developed general guidelines for conducting the field studies, acquiring data, and presenting the data in a final report. This required that North Star develop a format that could be used for all pool reports so that the series of reports would have maximum use and comparability.

Analysis of Socioeconomic Activities

The socioeconomic analysis for all pools in the study area was conducted by a team including Dr. C.W. Rudelius of the University of Minnesota and Mr. W.L.K. Schwarz of North Star. The socioeconomic impacts were analyzed by the same team for all fourteen segments of the Northern Section because substantial econonomies in data collection were possible with this approach.

The initial data for each pool were collected and then were submitted for review and updating to the investigator analyzing the natural systems for that pool. The suggestions of these investigators were incorporated in the socio-economic portions of each pool report.

Report Objectives

The Corps is required to submit an environmental impact statement for each pool and tributary in the Northern Section on which they carry out operation and maintenance activities; thus, as far as is practical, this study was carried out by pools.

The present report deals only with the St. Croix River from Stillwater, Minnesota, downstream to its mouth, which is described in detail in subsequent pages. Other reports in this series deal with the other pools and tributaries comprising the Northern Section of the Upper Mississippi River. Background information that applies to two or more pools in the study area appears as a portion of each appropriate report. This is necessary since the report on each pool must be capable of being read and understood by readers who are interested in only a single pool.

The overall objectives of this report are to identify and provide an assessment of the impacts of the Corps of Engineers activities related to the St. Croix River. Specifically, following this section, the report is in the format required for the environmental impact statement, and seeks:

1. To identify the environmental, social and economic impacts of the Corps activities related to the St. Croix River.
2. To identify and, where possible, measure the beneficial contributions and detrimental aspects of these impacts and draw overall conclusions about the net effects of Corps activities.

3. To recommend actions and possible alternative methods of operations that should be taken by the Corps of Engineers, other public agencies, and private groups to reduce detrimental aspects of the project.
4. To identify additional specific research needs to assess the impacts and increase the net benefits of Corps operations.

The report includes an analysis of natural and socioeconomic systems. The natural systems include terrestrial and aquatic plant and animal life as well as the nature of the land and quality of the water. This includes the habitats of rare and endangered species and tracts of special value for environmental education.

Socioeconomic systems include industrial activities, such as income and employment generated by barge traffic or activities in operating the locks and dams; recreational activities, such as fishing, boating, or hunting that are related to Corps operations; and cultural considerations, which include archaeological and historical sites.

1. PROJECT DESCRIPTION

The present Corps of Engineers' project in the St. Croix River consists of maintenance of a channel of 9-feet minimum depth for commercial navigation from Prescott upstream to Stillwater. A 3-foot channel is authorized from Stillwater to Taylor's Falls, but is not actively maintained. Maintenance consists of dredging and clearing of debris from the river from Stillwater, Minnesota, downstream to Prescott, Wisconsin (St. Croix River Mile 25.0 to 0.0, see Figure 1). The navigation channel in the St. Croix River is actually an extension of Pool 3, but for the purposes of this study, it is considered a separate pool.

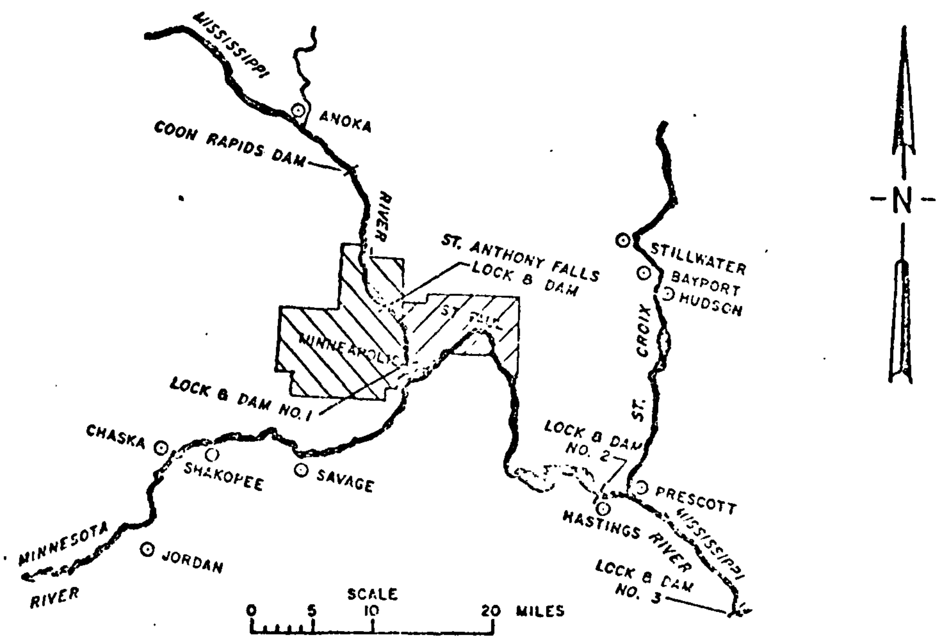

Figure 1. The Mississippi River and Its Major Tributaries in the Twin Cities Area (FWPCA, 1966)

AUTHORIZATION

Congress authorized the present 9-foot project on the Mississippi River with the Rivers and Harbors Act of July 30, 1930, as amended by Public Resolution No. 10, February 24, 1932, and by the Act of August 26, 1937 (see Table 1). The 9-foot channel was extended up the St. Croix River to Stillwater by the Act of December 16, 1931. Earlier acts provided for channels of less depth by means of channel constriction by wing dams and maintenance dredging.

HISTORY

In 1824, a year after the sternwheeler "Virginia" initiated navigation of the Mississippi River to Fort Snelling, Congress authorized the Corps of Engineers to improve navigation by removing snags, wrecks, shoals and sandbars (Ryder, 1972).

Table 1. Congressional Authorizations Pertinent to the Corps of Engineers' 9-Foot Navigation Channel in the St. Croix River (OCE, 1970)

Project Depth	Rivers and Harbors Acts	Work Authorized	Congressional Documents
9 feet	July 3, 1930, amended by P.R.10	Modify permanent structures under construction to accommodate 9-ft channel; Chief of Engineers granted discretionary authority to modify plans as deemed advisable.	House Document 290, 71st Congress, 2nd Session
	December 16, 1931	Project extended to Stillwater	House Document 184, 72nd Congress, 1st Session
	August 26, 1937	9-ft channel from Illinois River to Minneapolis	House Document 137, 2nd Congress, 1st Session

The 3-Foot Channel

The first comprehensive improvement of the Mississippi River for navigation was authorized by the Rivers and Harbors Act of June 18, 1878, to obtain a 4.5-foot channel from the mouth of the Missouri River to St. Paul by means of wing dams and other structures. Concomitantly, a 3-foot channel was authorized for the St. Croix River from its mouth upstream to Taylor's Falls (see Table 2). In the St. Croix only one wing dam was constructed, at approximately a right angle to the current at St. Mary's Point (Mile 11.8) sometime between 1878 and 1910. Its function was to direct the current toward the main channel at this bend. This structure may still exist; if so, it is presently submerged and covered by a sandbar. This wing dam and similar structures were built of alternate layers of brush bundles and rock (see Figure 2). No closing dams or longitudinal dikes were built in the St. Croix River.

Table 2. Congressional Authorizations Pertinent to the Corps of Engineers' Navigation Project on the St. Croix River Prior to the 9-foot Channel (Secretary of War, 1931)

Project Depth	Rivers and Harbors Acts	Work Authorized	Congressional Documents
3-foot	January 30, 1875	Survey of St. Croix River from St. Croix Falls to mouth.	None
	July 18, 1878	Project adopted from mouth to Taylor's Falls.	House Document 75, pt 6, 43rd Congress, 2nd Session
	January 26, 1880	Construction of dams, jetties, shore protection; dredging and removing obstructions from Taylor's Falls to Prescott.	House Document 40, 46th Congress, 2nd Session
	March 15, 1906	Maintenance of channel from Taylor's Falls to mouth.	House Document 686, 59th Congress, 1st Session
6-foot	January 21, 1927	Project extended to Stillwater for channel 500 feet wide.	House Document 378, 69th Congress, 1st Session

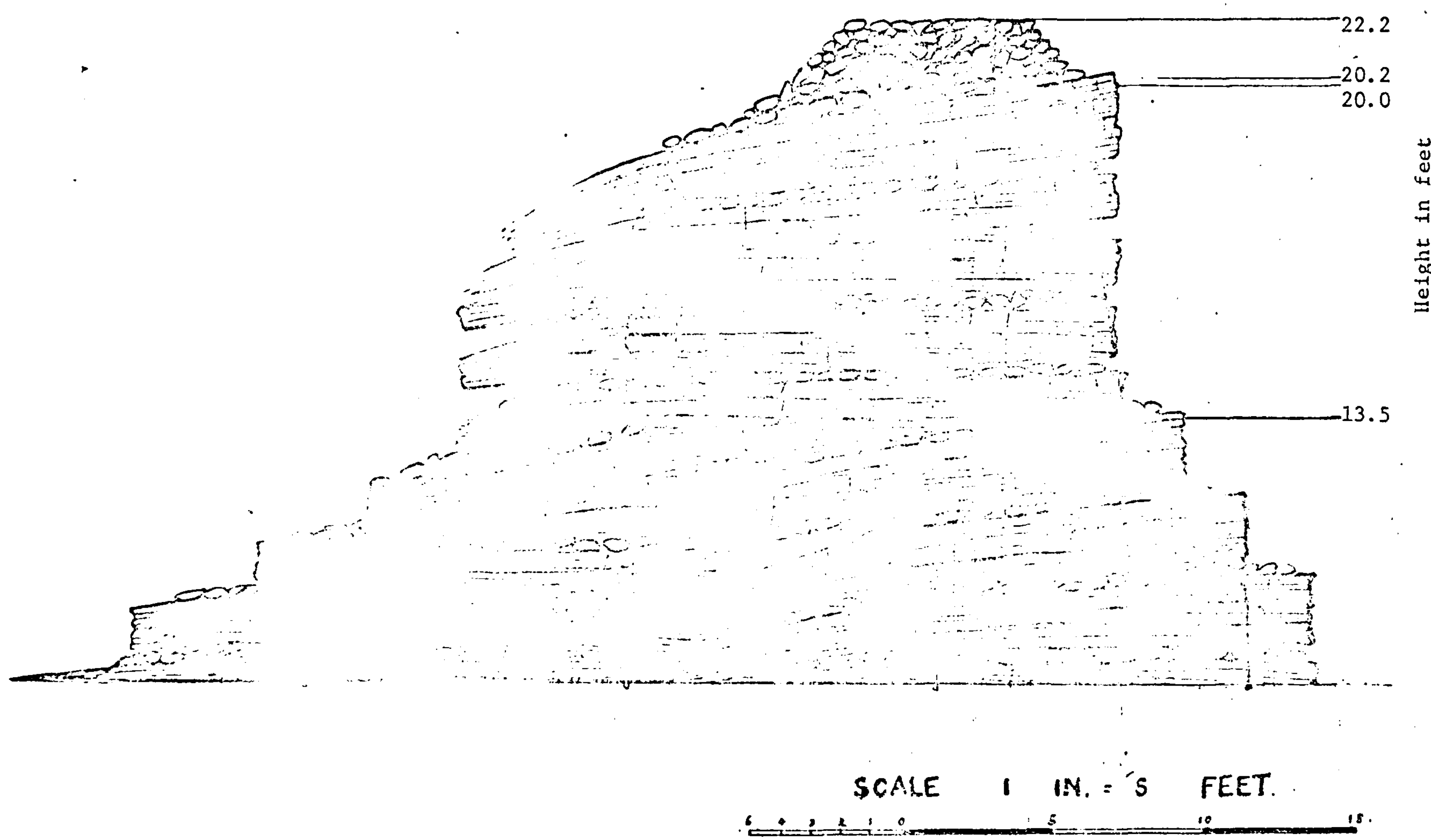

Figure 2. Cross Sections of Rock and Brush Wing Dams
(SW, 1908)

The 6-Foot Channel

The 6-foot channel in the Mississippi River was authorized by the Rivers and Harbors Act of 1907, but was not extended up the St. Croix until the Act of 1927.

Numerous surveys of the Mississippi River have been made by the Corps since the mid-1860's, several of which have been published as a series of charts. However, only charts of the 1926 and 1930 surveys of the St. Croix River, Taylor's Falls to the mouth, are available.

The 9-Foot Channel

As mentioned previously, the 9-foot channel project was authorized in 1930. It became operational in Lake St. Croix in 1938 with the completion of construction of Lock and Dam 3 and the filling of the pool to design leve . The current edition (1972) of the Navigation Charts is based on the 1964 aerial survey and presents updated information of the 9-foot channel in a more compact format than previously, although the arrangement of these charts is extremely inconvenient.

CORPS OPERATIONS AND MAINTENANCE

Presently the Corps of Engineers' project in the St. Croix River consists solely of maintenance dredging of the 9-foot navigation channel from Stillwater, Minnesota downstream to Prescott, Wisconsin (see Figure 3). No locks or dams are operated by the Corps in the St. Croix River. This segment is in an area of the river which widens naturally into a broad reach known as Lake St. Croix. Pool elevation is 675 feet above sea level (1912 adjustment) and was obtained in 1936 by the construction of Lock and Dam 3 near Red Wing, Minnesota, resulting in a 5.5-foot increase above the original lake level (Secretary of War,1932).

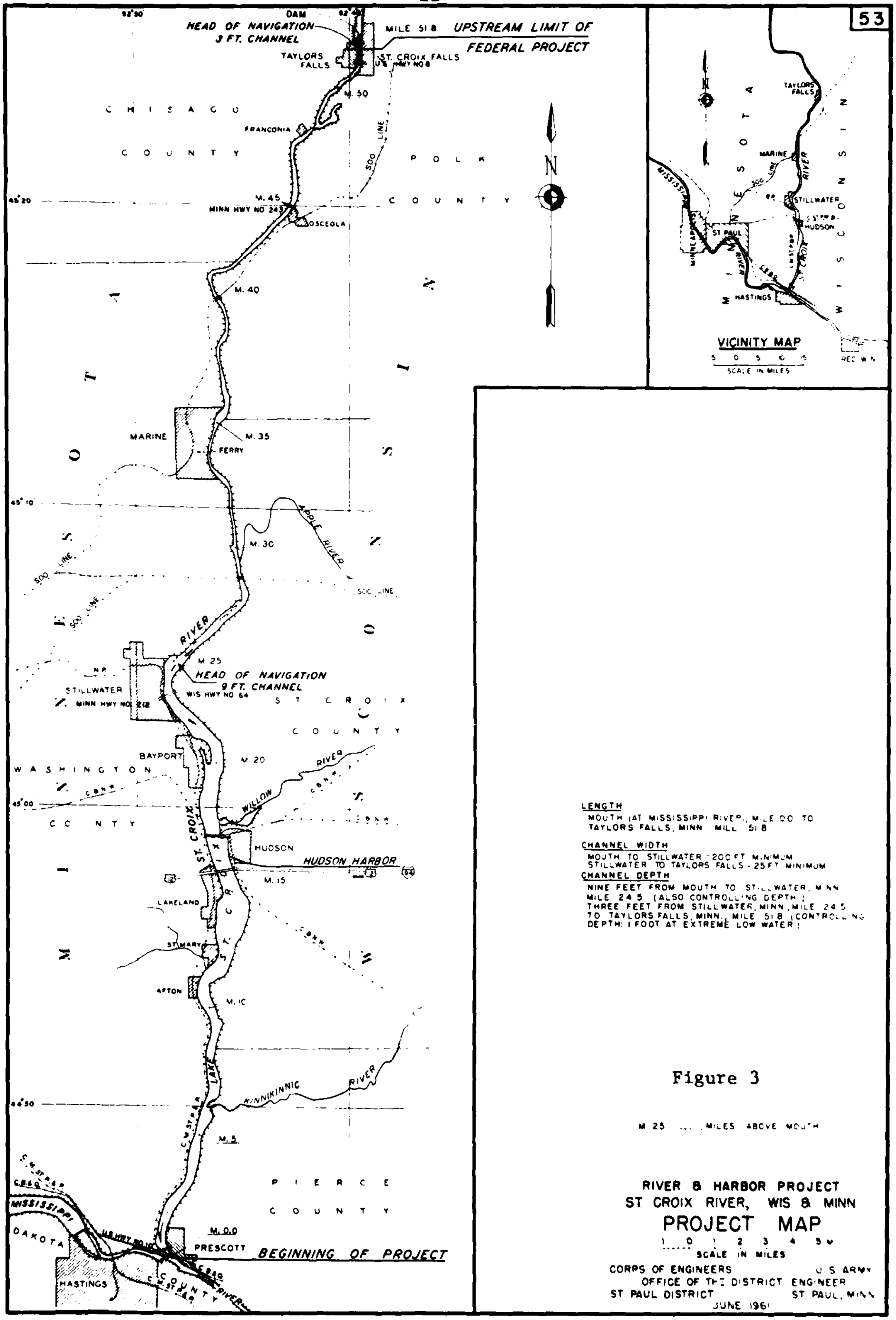
53
HEAD OF NAVIGATION 3 FT. CHANNEL
DAM
MILE 51.8 UPSTREAM LIMIT OF FEDERAL PROJECT
TAYLORS FALLS
ST. CROIX FALLS
M. 50
CHISAGO COUNTY
FRANCONIA
SOO LINE
POLK COUNTY
M. 45
MINN HWY NO 243
OSCEOLA
M. 40
MARINE
M. 35
FERRY
M. 30
APPLE RIVER
SOO LINE
RIVER
M. 25
HEAD OF NAVIGATION 9 FT. CHANNEL
STILLWATER
MINN HWY NO 212
WIS HWY NO 64
ST. CROIX COUNTY
BAYPORT
M. 20
WASHINGTON COUNTY
WILLOW RIVER
ST. CROIX
HUDSON
HUDSON HARBOR
M. 15
LAKELAND
ST MARY
AFTON
M. 10
LAKE
KINNIKINNIC RIVER
M. 5
MISSISSIPPI
DAKOTA COUNTY
HASTINGS
PIERCE COUNTY
M. 0.0
PRESCOTT
BEGINNING OF PROJECT
MINNESOTA
WISCONSIN
VICINITY MAP
SCALE IN MILES
MARINE
STILLWATER
HUDSON
ST PAUL
HASTINGS
LENGTH
MOUTH (AT MISSISSIPPI RIVER), MILE 0.0 TO TAYLORS FALLS, MINN MILE 51.8
CHANNEL WIDTH
MOUTH TO STILLWATER - 200 FT MINIMUM
STILLWATER TO TAYLORS FALLS - 25 FT MINIMUM
CHANNEL DEPTH
NINE FEET FROM MOUTH TO STILLWATER, MINN MILE 24.5 (ALSO CONTROLLING DEPTH)
THREE FEET FROM STILLWATER, MINN, MILE 24.5 TO TAYLORS FALLS, MINN., MILE 51.8 (CONTROLLING DEPTH: 1 FOOT AT EXTREME LOW WATER)
M 25 ...... MILES ABOVE MOUTH
RIVER & HARBOR PROJECT
ST CROIX RIVER, WIS & MINN
PROJECT MAP
SCALE IN MILES
CORPS OF ENGINEERS U S ARMY
OFFICE OF THE DISTRICT ENGINEER
ST PAUL DISTRICT ST PAUL, MINN
JUNE 1961

Figure 3

Maintenance dredging is necessary because, during the year, changes in the ability of the current to keep its suspended sediment load continually in suspension (hydraulic efficiency) results in sediment accumulation. These areas are dredged by the Corps to remove this hazard to commercial navigation. For this purpose, equipment such as the hydraulic dredge "Thompson" is used (see Figures 4 and 5).

Dredging operations to maintain the nine-foot channel begain in the 1930's and presently result in an average of 42,000 cubic yards annually, or 1676 cubic yards per river mile (S.P.D.-NCS, 1973, see Table 3 and Figure 6). Maintenance dredging is necessary mainly at the mouth of the Kinnickinnic River, and infrequently at Hudson, Wisconsin, and Catfish Bar (see Figure 1 in Appendix A.IV).

Figure 4. Aerial view of the hydraulic dredge "W. A. Thompson", showing discharge of spoil carried by sections of floating and shorepipe (BSFW - Don Vogtman)

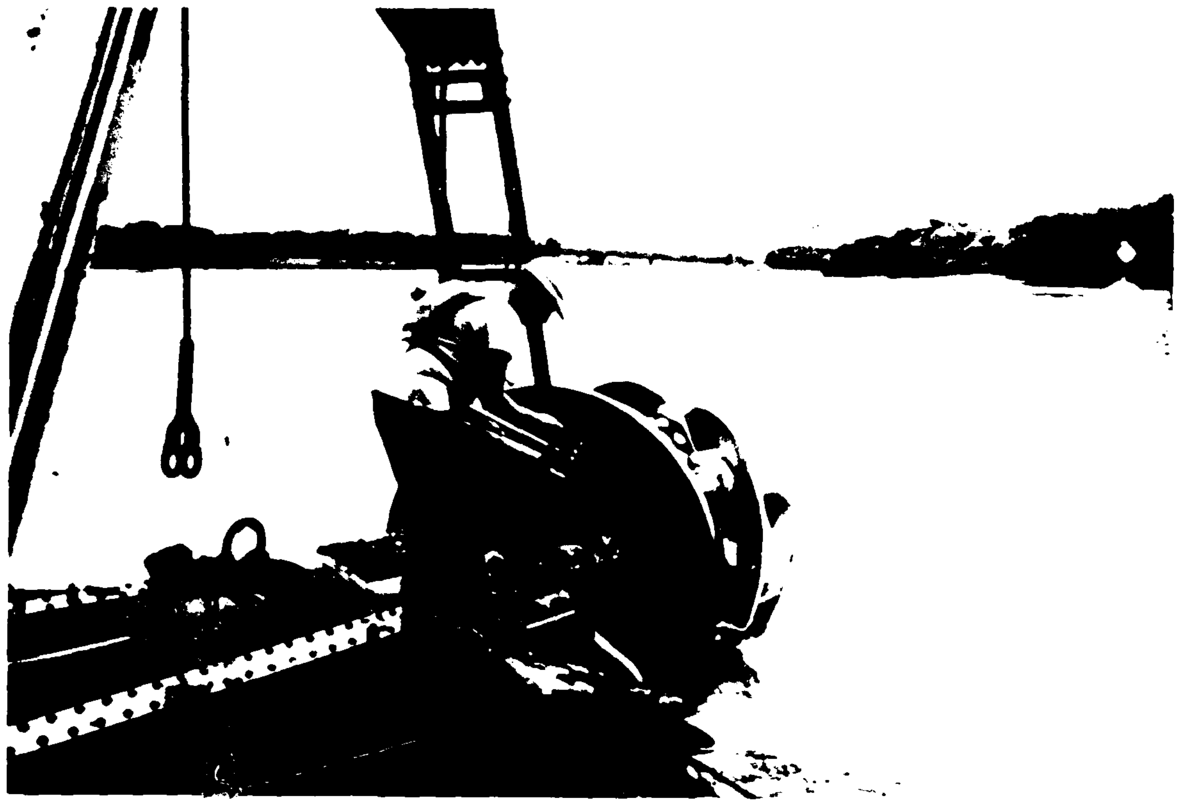

Figure 5. Bow of Dredge Thompson showing cutter head (BSFW - Don Vogtman)

Table 3. Annual Volume of Sediment in Cubic Yards, and Annual Volume/River Mile, Dredged from St. Croix River from 1930 to the Present (S.P.D.-NCS, 1972)

Year	Volume	Year	Volume
1930		1955	
1931		1956	43,603
1932		1957	
1933		1958	41,816
1934	60,863	1959	
1935		1960	
1936	40,352	1961	33,176
1937	124,557	1962	
1938		1963	
1939		1964	
1940	103,886	1965	
1941		1966	36,725
1942		1967	136,421
1943		1968	338,246
1944		1969	
1945	351,831	1970	
1946		1971	
1947		1972	36,159
1948	86,079		
1949	11,167		
1950	30,657		
1951			
1952			
1953			
1954	117,051		

Since 1934, Av. 41,910 cu.yd.

Average annual volume per river mile: 1676 cu. yd/mile

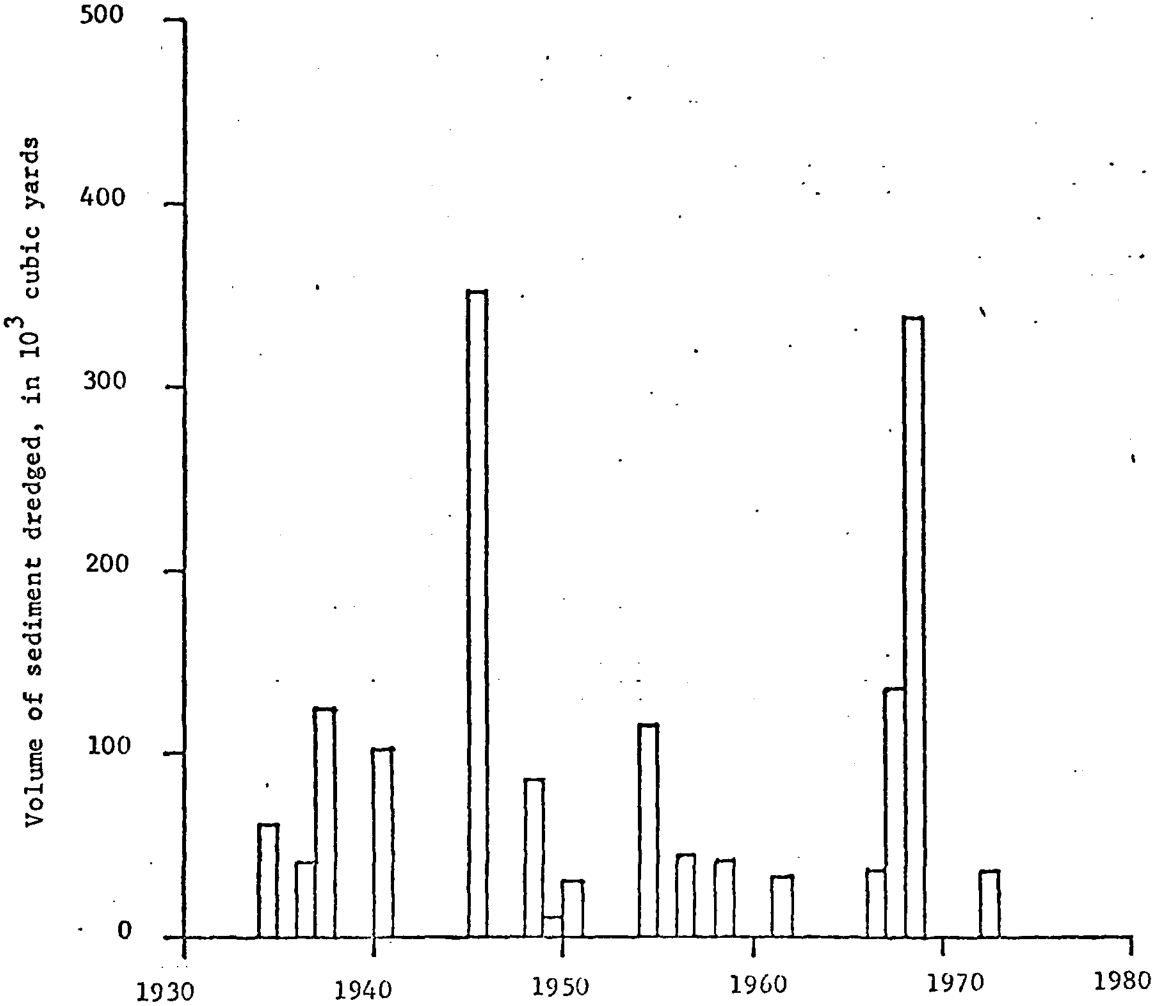

Figure 6. Annual volume of sediment dredged from the St. Croix River from 1930 to the present (S.P.D.-NCS, 1973)

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2. ENVIRONMENTAL SETTING

NATURAL SETTING

The Corps of Engineers' 9-foot channel project in the St. Croix River is located in the lower 25 miles of this river, in the broadened, bluff-bordered, lake-like reach known as Lake St. Croix (see Figure 7). The present lake level is maintained by Lock and Dam 3, and hence is at the same elevation as Pool 3. However, in this study, the 9-foot channel project in Lake St.Croix is considered separately from Pool 3.

Since this is an on-going project, the present natural environmental setting encompasses the existence of the project in Lake St. Croix; *i.e.*, the time span since completion of Lock and Dam 3 in 1938. The environmental setting without the project, in this case prior to the 9-foot project, must be reconstructed from published information.

Ecosystem Subdivisions

The ecosystems of Lake St. Croix may be divided into several reaches and into various component parts for more detailed description.

Reaches of Lake St. Croix

Two reaches, the Upper and Lower, may be conveniently designated (see Figure 7). The Upper Reach incorporates the more intensely urbanized upstream portion of Lake St. Croix, from Stillwater, Minnesota, downstream to Hudson, Wisconsin (St. Croix River Mile 25.0 to 16.0). However, two small towns and numerous homes occur farther downstream along the Minnesota river bluffs to Afton (Mile 11.0). The Upper Reach is the area of the Lake in which barge terminals are located and several ecological studies have been conducted.

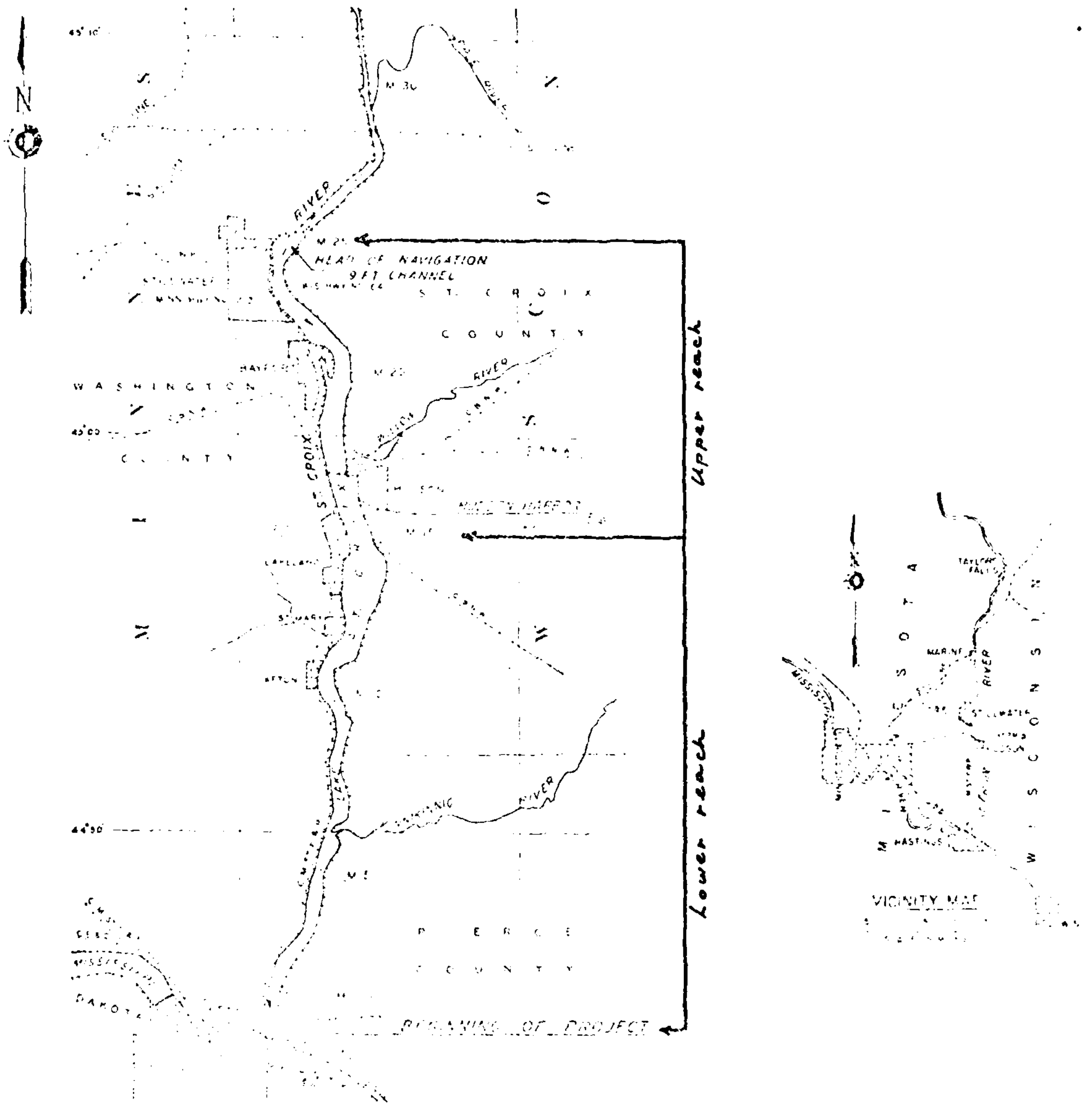


Figure 7. Lake St. Croix Portion of the St. Croix River, Wisconsin and Minnesota (S.P.D.-NCS, 1961)

The more natural-appearing Lower Reach then is taken from Hudson downstream to the mouth of the St. Croix at Prescott, Wisconsin (Mile 16.0 to 0.0). In the Lower Reach there are no barge terminals and few ecological studies have been undertaken in the river valley.

Ecosystem Elements

The various ecosystem elements of the Lake St. Croix valley may be divided into Physical Aspects and Biological Aspects sections, the first of which includes geologic, climatic, and hydrologic components. The Biological Aspects section includes floral and faunal components as part of terrestrial and aquatic ecosystems.

However, it should be remembered that such divisions may hide some of the numerous complex interactions not only between components within these river valley ecosystems, but also with those components elsewhere in the drainage basin as well. Thus, wherever possible, the characteristics of components in the Lake St. Croix valley will be discussed in relation to the Lake St. Croix area as well as to the whole watershed. Interactions with areas outside of the watershed will be dealt with in a very general manner, if at all.

Physical Aspects

Topography

The St. Croix River originates in Upper St. Croix Lake, Douglas County, Wisconsin. From its source in Wisconsin's northern highland region, the St. Croix flows 157 miles in a southerly direction, between Minnesota's Central lowland and Wisconsin's southwestern upland, to join the Mississippi River at Prescott, Wisconsin (see Figure 7). This major tributary of the Upper Mississippi drains a 7650 square mile basin (see Figure 8), which consists of gently rolling to hilly forested, agricultural and urban lands. This topography is derived

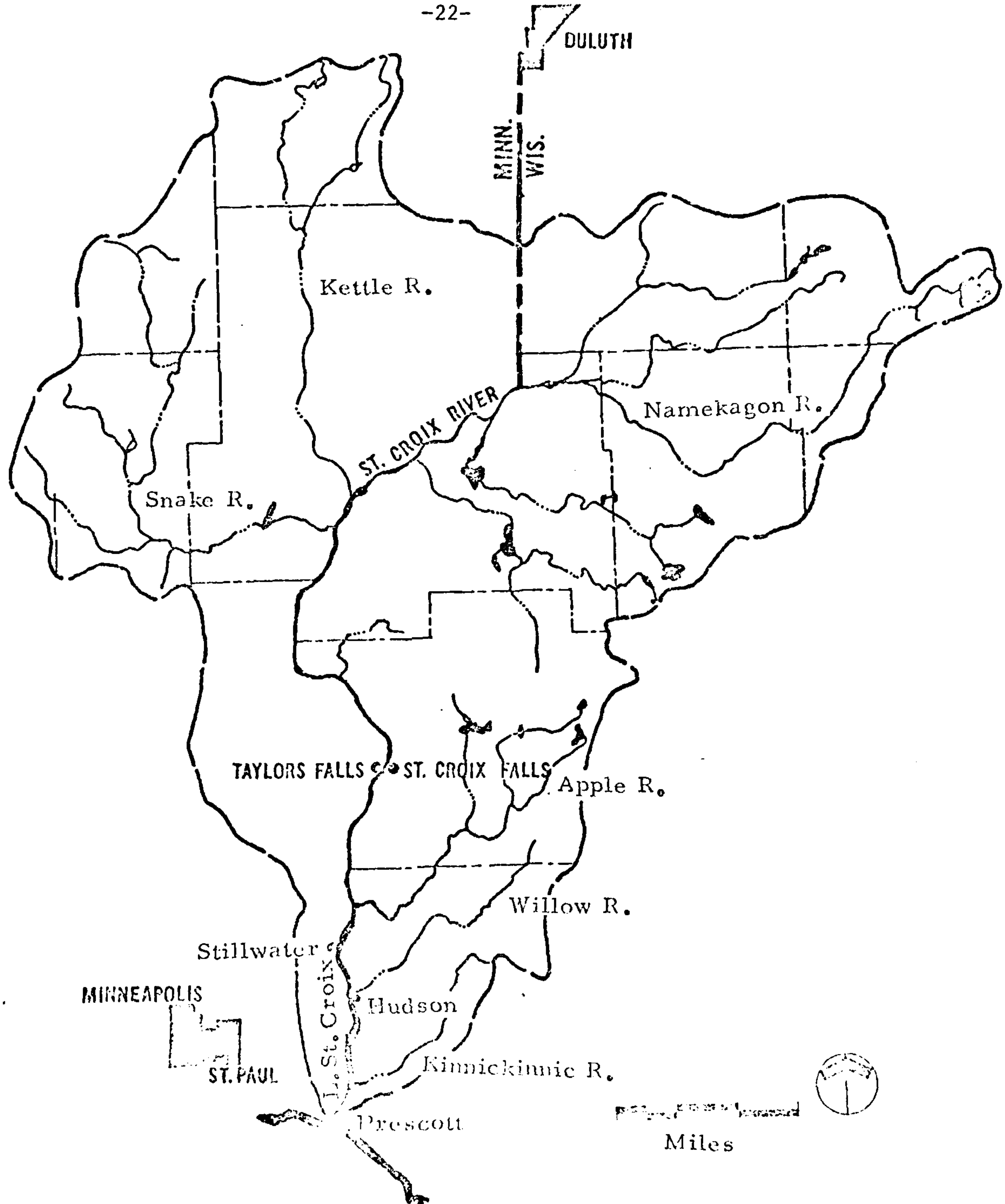


Figure 8. Watershed of the St. Croix River (NSP, 1969)

mainly from the Pleistocene glaciers during the last million years, as subsequently modified by erosion, and more recently, by people. This topography, plus a climate which increases in moisture from west to east, the soils, and man's activities have led to a vegetational gradation. This gradation extends from the large mixed pine-hardwood forest studded with numerous lakes and streams in the northeast, to the rich, open farmland (much of which was formerly prairie) downstream dotted with marshes and laced with streams.

Downstream from Sunrise (Pine County, Minnesota) the St. Croix River leaves a broad, shallow, swampy valley and flows between rocky bluffs towering 100 to 300 feet above its surface. The shape of the Lake St. Croix Valley is seen in the profiles of the river valley at the standard transects (see Figure 9). At Taylors Falls, Minnesota, the water falls 60 feet at the hydroelectric power dam and then rushes through a narrow rocky gorge, the St. Croix Dalles, where the largest gradient (8 feet per mile) occurs. The current slows in the lower 24 miles of the River, which is essentially impounded by the higher bed of the Mississippi. Thus, a natural slackwater pool is formed, known as Lake St. Croix.

Geology

The St. Croix River watershed is underlain by a series of Precambrian and Cambrian igneous, metamorphic and sedimentary rocks (including basalt, sandstone, dolomite and shale) north of Taylor's Falls, Minnesota (Schwarz and Thiel, 1963; Hanson, 1971). Downstream this basin is underlain mainly by Cambrian and Ordovician sedimentary rocks (including sandstones, dolomite and shale (see Figures 10 and 11).

In the last million years at least four glaciers gouged their way across these rocks and through the Twin Cities area (see Figure 12), then receded and left hills and valleys formed from debris which they had transported long distances. Deposits left by the last one, the Wisconsin Glacier, were brought first from

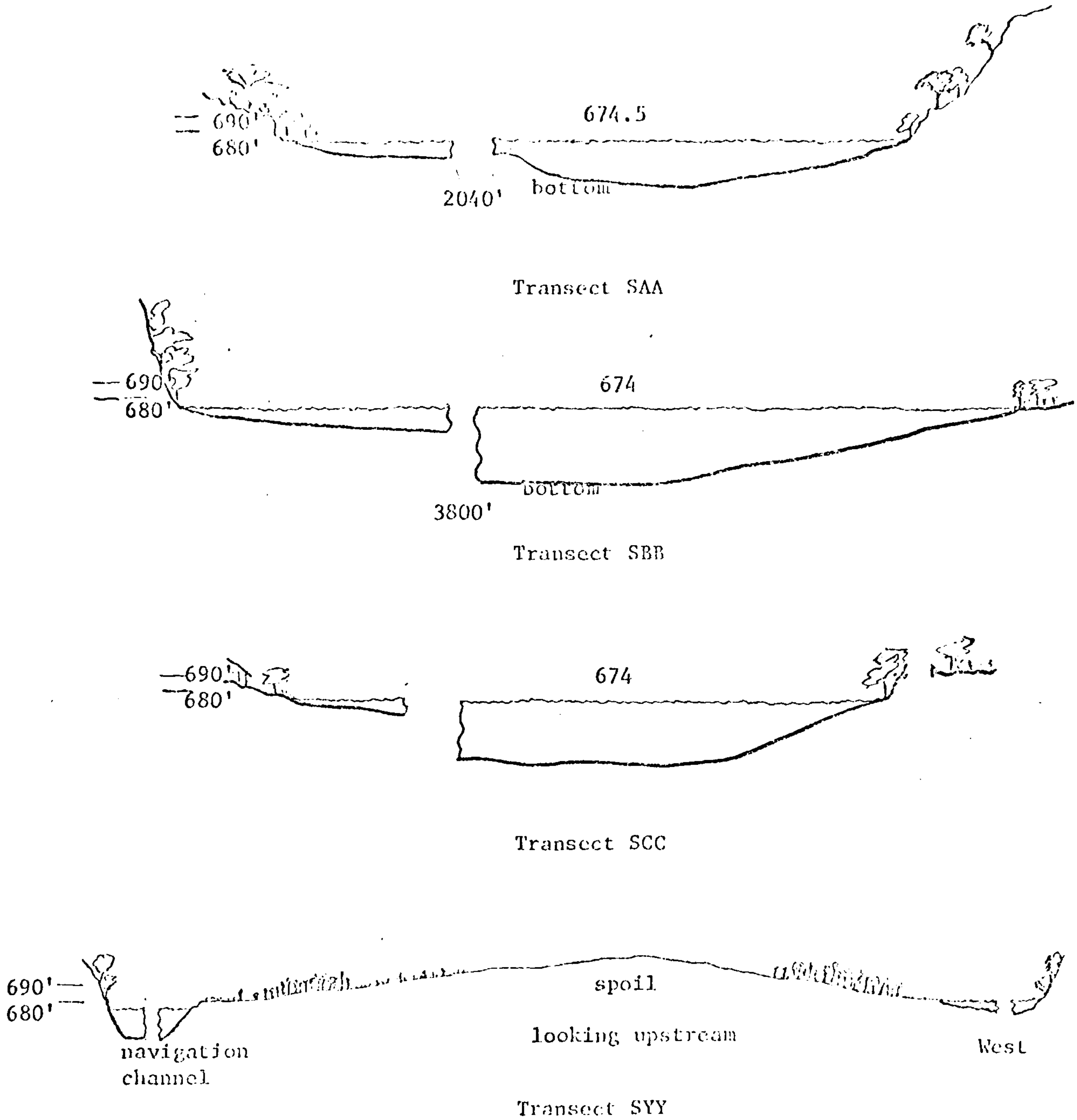


Figure 9. Schematic Diagram of Riverscape Profiles at each Standard Transect and One Special Transect on Lake St. Croix (Gudmundson)

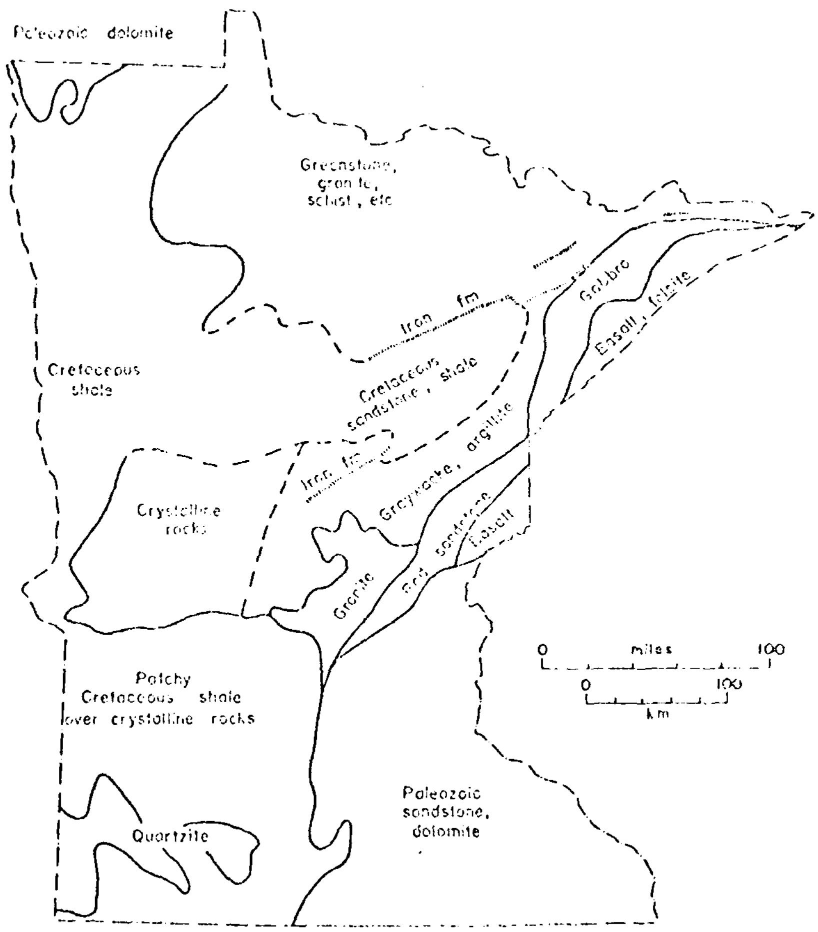


Figure 10. Bedrock Map of Minnesota (Minn. Geological Survey, 1969)

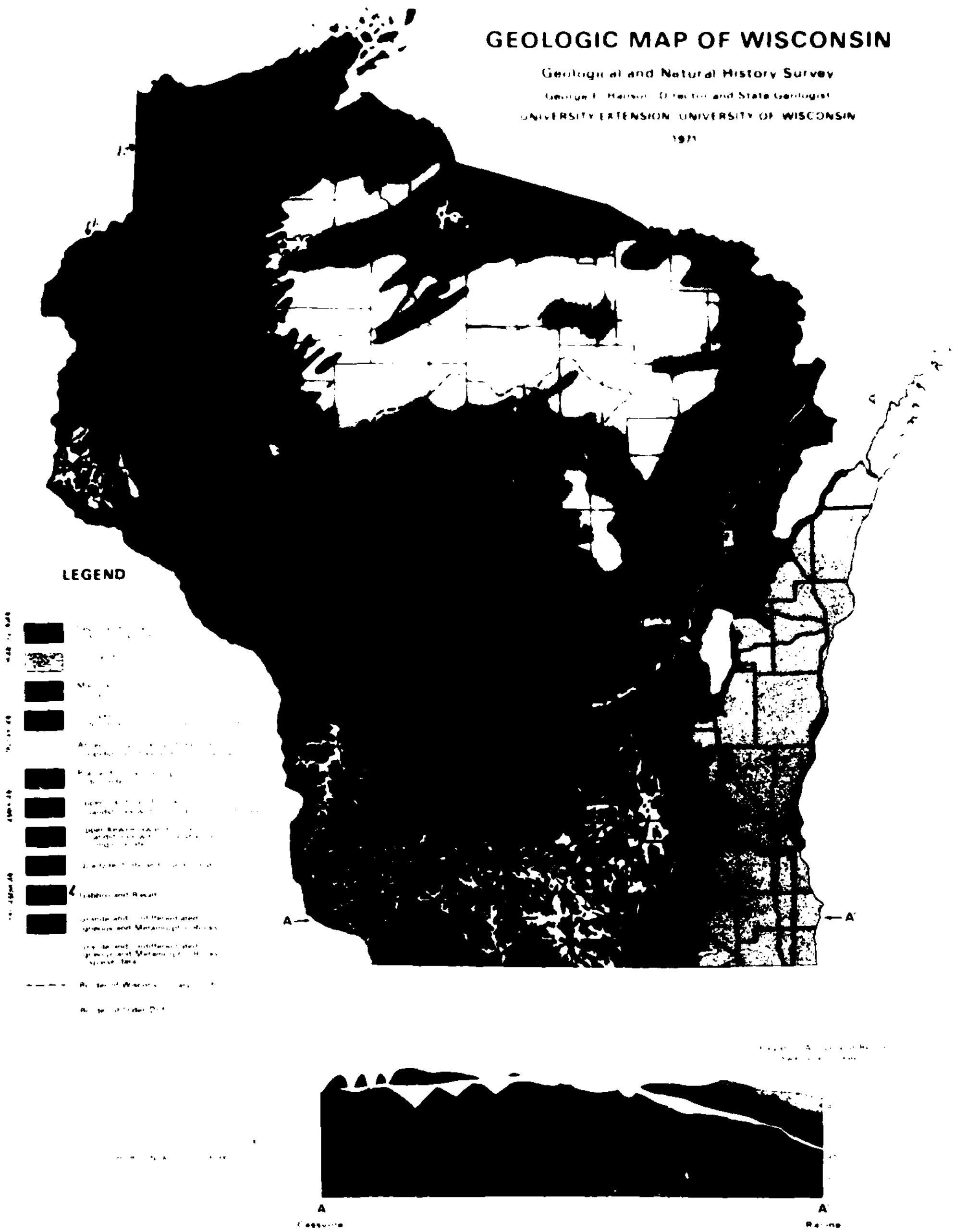


Figure 11. Geologic Map of Wisconsin (Hanson, 1971)

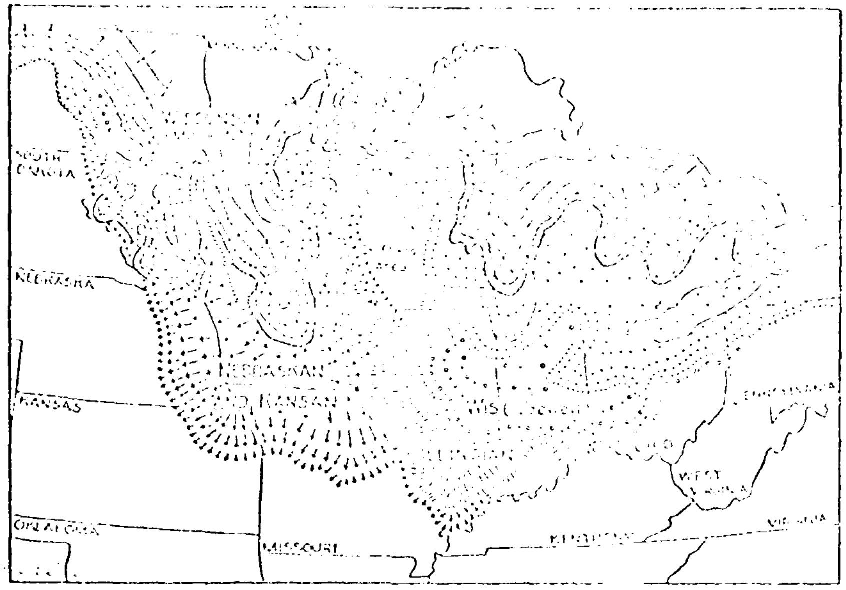


Figure 12. Map of Ice Sheets of the United States (Schwartz and Thiel, 1963)

the northeast by the Superior Lobe, and consist of red, sandy, and pebbly deposits (see Figure 13). Later, the Grantsburg Sublobe of the Des Moines Lobe brought buff-colored sands, clays, and rock from the Createceous shales, more or less covering much of the previous deposits. Those deposits which are unstratified are termed till; if they are transported and sorted according to size by glacial meltwaters, they are termed outwash.

Thus, several glacial advances stagnated at various times and places in Minnesota (and elsewhere), dumping large quantities of rock, stone, gravel, sand and clay. These mounds were formed at the terminus of the glaciers and generally conformed to their shape; thus, they are termed "end" or "terminal" moraines. These moraines and other tills and outwash, which have been subsequently modified by climate, vegetation, and man, form our present soils and topography.

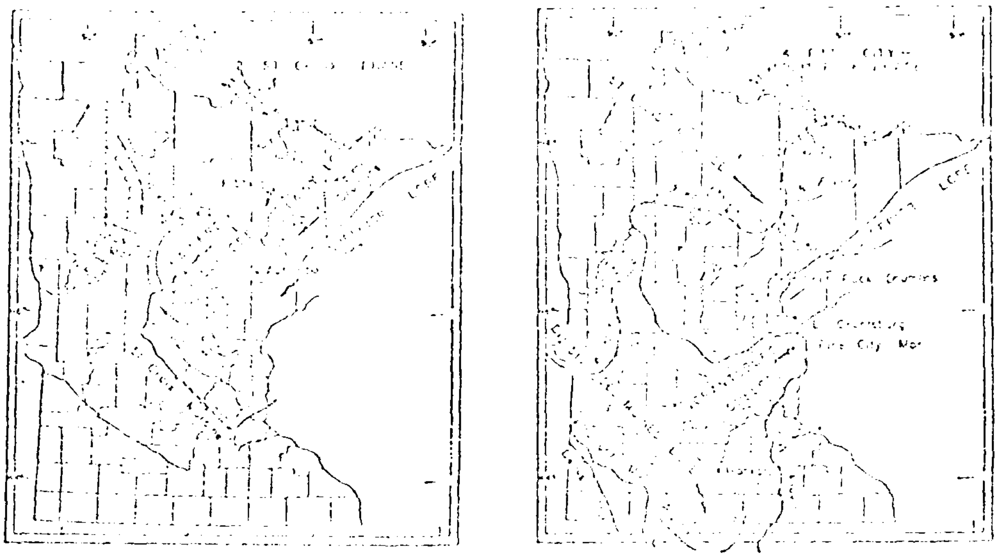


Figure 13. Maps of Minnesota Showing Extent of Ice Lobes During Various Phases of Wisconsin Glaciation (Winter and Norvitch, 1972)

The St. Croix Valley was formed in two stages by water from two glacial lakes. The lower valley, below the cities of Taylor's Falls in Minnesota and St. Croix Falls, Wisconsin, was created first. This section was carved out by water from glacial Lake Grantsburg which spread over the land from Grantsburg, Wisconsin, westward into east central Minnesota (see Figure 14). As the ice melted, this lake rose until it finally spilled over its banks at a point near Taylor's Falls and St. Croix Falls. There the water streamed southward, carving the lower St. Croix Valley to the Mississippi. Later, when the level of the lake fell, this glacial river ceased to flow. Eventually, glacial Lake Grantsburg also dried up, leaving a flat sandly plain.

As the Superior lobe of the great ice mass retreated, glacial Lake Nemadji was formed by water ponded between the retreating ice front and a divide at the southwestern corner of Lake Superior. This lake drained through

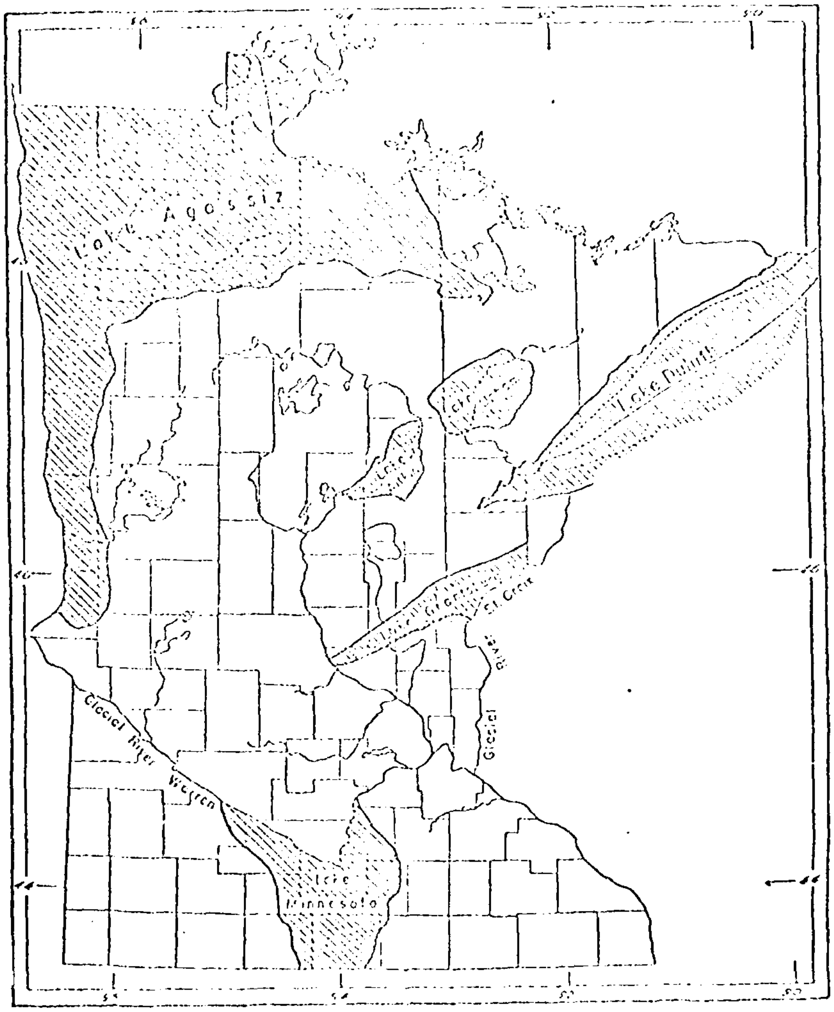


Figure 14. Map of Former Major Glacial Lakes and Rivers of Minnesota (Schwartz and Thiel, 1963)

an outlet discharging into the Kettle River and Glacial St. Croix River. Lake Nemadji later connected with glacial Lake Brule to become glacial Lake Duluth which drained into glacial St. Croix River. This large glacial river gouged a deep valley through basalt and sedimentary rocks, which is now partially filled (from Stillwater to Prescott) by fluvial sediment and Lake St. Croix.

This present lake grew as the St. Croix River became impounded by the Mississippi River. The Mississippi, which transports a greater sediment load, has deposited some of this sediment at Prescott, Wisconsin, raising its bed faster than has the St. Croix River. Thus, the Mississippi has formed a natural dam across the mouth of the St. Croix River (see Figure 1, Appendix A II).

As the continental glacier melted and decreased in weight and size, the earth's crust was relieved of a tremendous pressure. This pressure release caused the crust to rise and was accompanied by further retreat of the glacier. The result was that the St. Croix River no longer drained Glacial Lake Duluth but split to form two river valleys--the south-flowing St. Croix and the north-flowing Bois Brule (BOR, 1972).

Climate

The climate in the St. Croix River watershed varies from humid in the north to moist subhumid in the south. The average temperature varies from about 40°F to 44°F from north to south, while the normal total precipitation varies from 30 inches per year in the north to about 26 inches per year in the south. About 20 percent of this precipitation falls between November and March. Average wind velocities range from 6 to 12 miles per hour with storm winds, especially tornados, greatly exceeding this. Generally, the summer winds are southerly, bringing tropical air to the region, and winter winds bring Arctic air masses (S.L.D.-NCS, 1970).

Soils

The silt or sandy loam soils between Taylor's Falls and Stillwater form a thin cover over the bedrock.

From south of Bayport to Afton there are large, nearly level terraces composed of sand and gravel. There is very little alluvial land along this stretch of the river, but nearly level sand and gravel deltas and alluvial fans have formed at the mouth of almost every stream that flows into the river. These fans are often used for recreational purposes. Flooding is frequent on these fans and on the adjacent areas of alluvial land. There are several low sandy islands, bars and peninsulas in the lake that are frequently used for picnicking, and other river-oriented recreation. The sandbars are heavily used as beaches by recreational boaters and canoeists (BOR, 1972). Other low areas are residential or city parks (Stillwater, Hudson and Afton). However, there is relatively little floodplain adjacent to Lake St. Croix.

The soils along the Wisconsin bluff in Pierce County belong to the Dakota-Waukegan association, except those soils bordering Kinnickinnic River valley. This latter group of soils belong to the Antigo-Onamia association (SCS, 1968). Soils in both associations are moderately deep, loamy soils of stream terraces, the former dark-colored, the Antigo-Onamia group light-colored. The former group of soils developed under oak savanna while the Antigo-Onamia group developed under a hardwood forest.

The parent material of the 30 to 60 inches of the soil profile was loess, which is a fine particled material or "rock flour" in the glacial drift. This loess was eroded by the stong winds from the glaciers, transported and deposited in the lee of the bluffs.

The slope of these soils ranges from zero to 12 percent, occasionally up to 20 percent. The percolation rate is 0.8 to 2.5 inches per hour in the upper 30 inches. The sand substratum below, in the Dakota-Waukegan soils, have a percolation rate of 5 to 10 inches per hour. The sand and gravel below the Antigo-Onamia soil has a percolation rate exceeding 10 inches per hour.

Generally, the Dakota-Waukegan soils are well-suited to crops; however, they tend to be draughty and susceptible to wind erosion in the area adjacent to Lake St. Croix. The Antigo-Onamia soils in the Lake St. Croix area are also draughty and are generally suited for pasture and trees.

Land Use

The Upper Reach of Lake St. Croix, *i.e.*, on both sides from Stillwater to about Hudson (and right side to Afton) contains most of the towns and industry located on the lake. Here residential areas crowd the bluffs and floodplains, with commercial and industrial sites also on the latter. There has been a continuing increase in the number of residential units along the potentially highly erodable steep bluffs, particularly on the Wisconsin bluffs.

Presently bare soil areas occur extensively as beaches on the Wisconsin side and as spoil sites at the Kinnickinnic River (St. Croix Mile 5.5) and at Hudson (St. Croix Mile 16).

Groundwater

Large quantities of groundwater are present in the highly permeable surficial sand deposits. Many lakes and streams are located in these deposits. Rapid removal of groundwater from these aquifers generally induces water to mover from the lakes and streams. These aquifers supply 95 percent of the water outside of the large cities. They are similar in chemical composition from the Mississippi headwaters to the Twin Cities, except that in the Cities they have only one-tenth to one-hundredth of the iron content.

Little appears to be known regarding groundwater supplies available or used specifically in the St. Croix River watershed. The Prairie du Chien-Jordan aquifer in Minnesota supplies some groundwater from a recharge area located approximately between Forest Lake and Cottage Grove, Minnesota (see Figure 15). This groundwater is medium hard (average 412 ppm, 1961) and contains more dissolved solids, sulfates and bicarbonates, but less iron and chloride than the the softer water in the lower Mt. Simon-Hinckley aquifer (U.S.G.S., 1970).

Surface Hydrology

Runoff in the St. Croix River watershed varies from 15 inches in the northeasternmost extent to about five inches in the southwest. Evaporation is greatest in the southern portion at 31 inches, and decreases to about 26 inches in the northeast (U.S.G.S., 1970a).

Biological Aspects

Terrestrial Vegetation

The early logging operations of the Lower St. Croix Valley left few of the original white pine or red pine stands except in isolated, steep-sloped areas where a few virgin tracts of these stately conifers still exist (BOR, 1972). The remaining pine are mainly second growth, principally located on the higher ground. They are intermixed with elm, oaks, ironwood and silver and sugar maple. Basswood, hackberry, dogwood, paper birch, and aspen occur but less frequently (see Tables 1 and 2 in Appendix A. IV).

Several species of deciduous trees densely vegetate thousands of acres along the river valley. Boxelder, silver maple, elm, ash, and cottonwood are well represented in this zone. Forming an understory, and in cutover areas as well, are such species as chokecherry, dogwood, mountain maple, thorn apple, high bush cranberry, and elderberry.

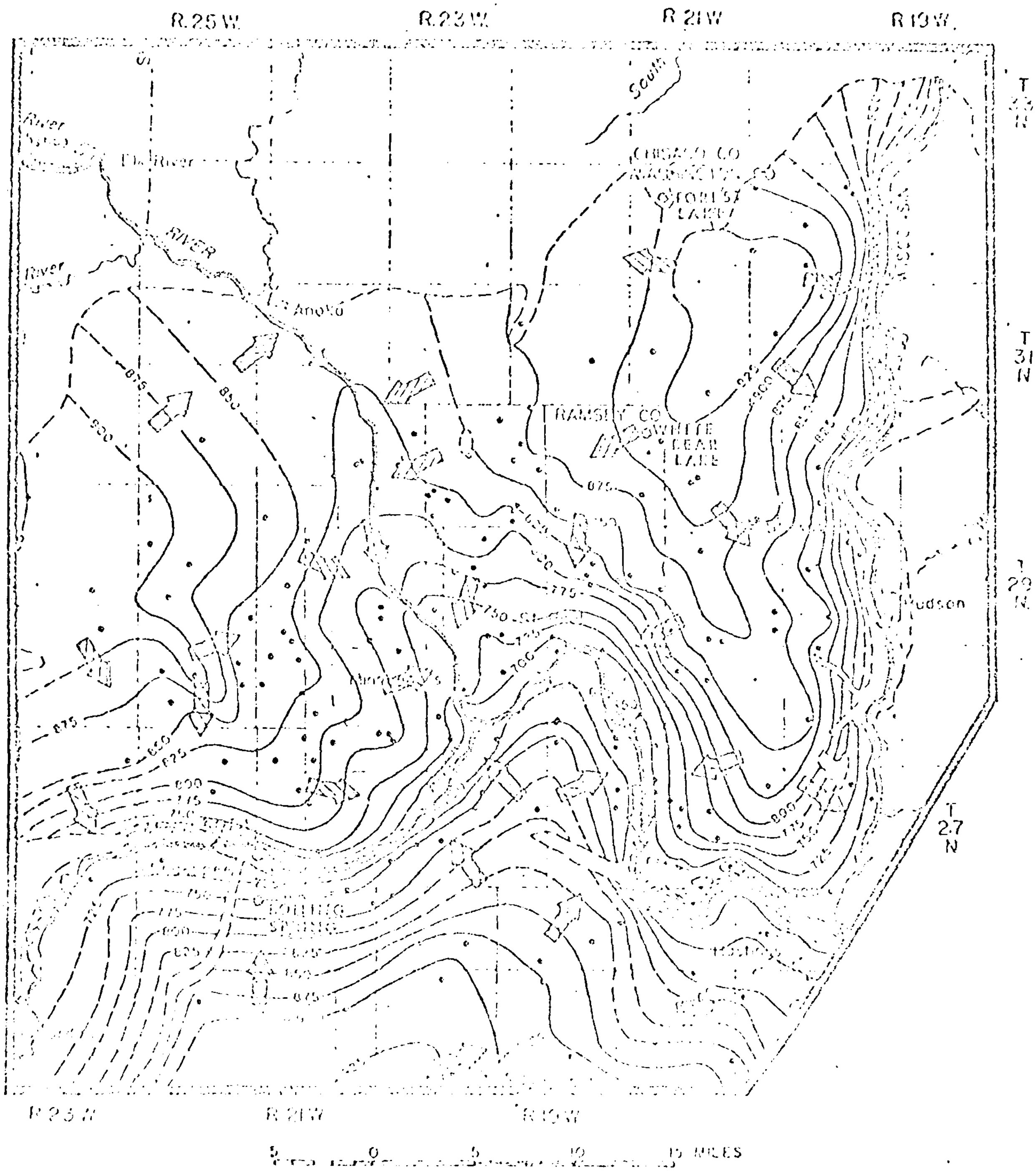


Figure 15. Potentiometric Surface of Water in the Prairie du Chien-Jordan Aquifer in Winter 1970-71, in the Minneapolis-St. Paul Area (Winter and Norvitch, 1972)

Periodic flooding of the lowlands has resulted in a river bottom vegetation favoring hydrophytic species along many parts of the river. Willow and alder appear mainly around the spoil sites.

Ground-cover plants are both numerous and varied. They range from primitive mosses and lichens through ferns, fungi, and seed plants. A great variety of mushrooms may be found here, including the very desirable morel or sponge mushroom.

Flowering plants of interest include the trillium, anemone, water marigold, wild strawberry, jack-in-the-pulpit, skunk cabbage, Solomon's seal, wild geranium, forget-me-not, asters, goldenrod, and wild rose. Some less popular species include poison ivy, stinging nettle, and beggar's ticks.

Various flowering shrubs are of value to both people and wildlife. They include chokecherry, juneberry, dogwood, snowberry, elderberry, wild grape, pincherry, raspberry, and highbush cranberry.

Relatively steep slopes and riverbottoms offer a variety of habitats that enhance the ecological diversity of the area. An outstanding area of botanical interest occurs in the lower Kinnickinnic River Valley. An ongoing study of the Kinnickinnic Valley is being conducted by the Wisconsin State University--River Falls. In a preliminary report from the University, it states:

> "Presently about 1900 species of plants in 123 families and 535 genera are found in Wisconsin. Of this number 60 families, 148 genera, and 240 species of vascular plants have been identified from this valley and filed in the herbarium at Wisconsin State University, River Falls. However, this is by far an incomplete record of the vascular plants occurring in the valley. Potentially the valley may contain as many as 400-500 species of vascular plants to the list, the total composition of the valley will be considerably higher (BOR, 1972).

A grassy slope with scattered red cedars occurs near the blufftop on the left bank (Wisconsin side) at St. Croix Mile 20. This site is a remnant of a savanna community, the prairie segment of which formerly had a wider distribution. Less than 100 acres of undisturbed cedar savanna are known to occur in Wisconsin. This community type is listed as an uncommon plant community in Wisconsin (WIDNR, 1973).

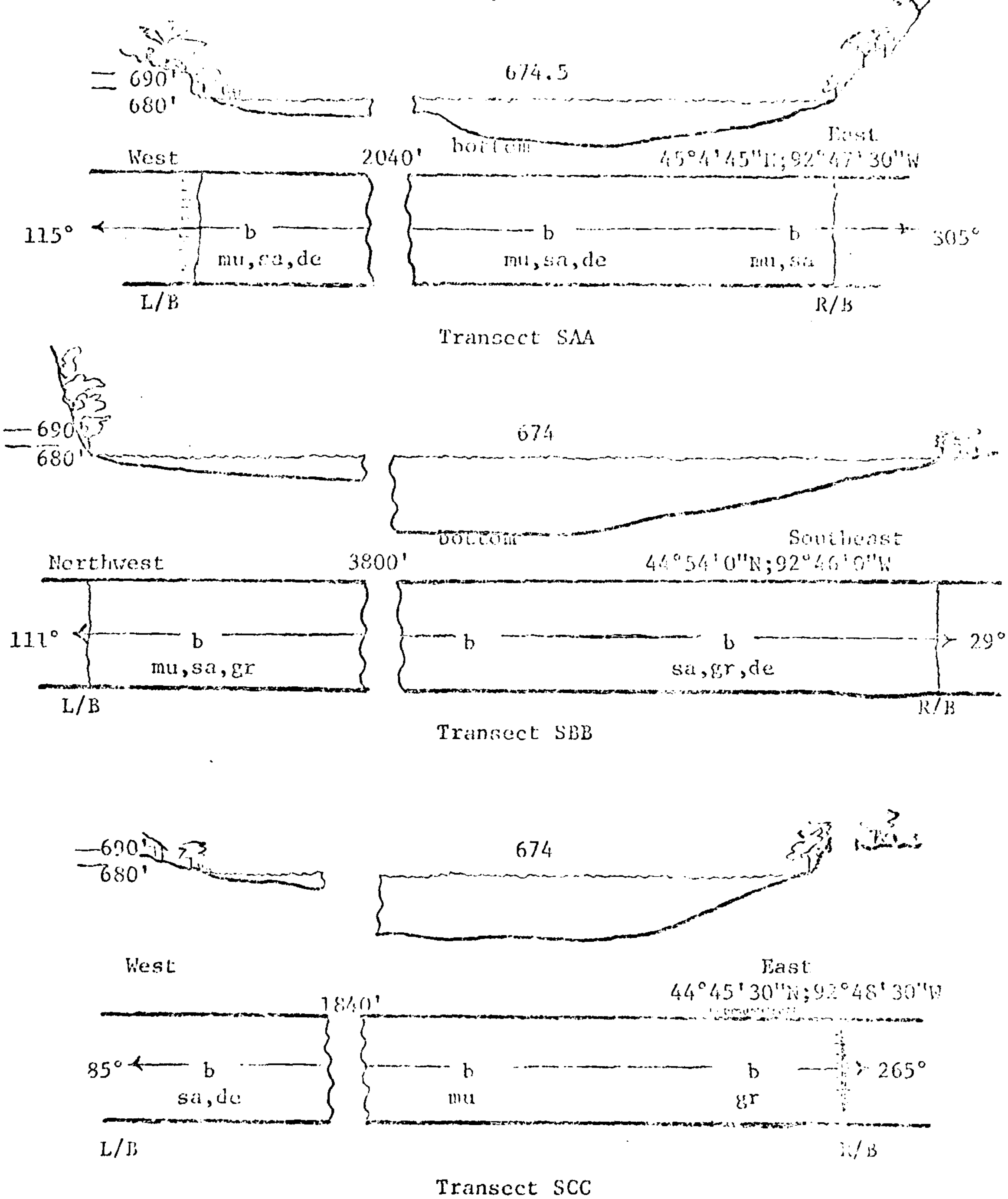
The abundance of vegetation was determined on all standard and special transects in 1973 (see Table 2 in Appendix A IV). Floodplain habitat was encountered on Transect SAA, right bank; and on Transect SYY left bank (Spoil). Bluff slope habitat occurred on Transect SAA, left bank plateau; and on Transects SBB, SYY, and SCC (see Figure 16).

The floodplain vegetation on the Transect SAA consisted of a tree canopy, including elms, sand-bar and other willows and river maple (see Table 4). A shrub layer was absent. The herb layer consisted of grasses, dog banes, elder, nettle, chickweed and asters. Near the shoreline and up along a small spring grew horsetails and spotted jewelweed. A low area which was flooded at the time of sampling had cattails and sedges; nearby, also were watercress and duckweed.

Trees on the bluff slopes include river maple, cottonwood, ash, elm, and willows along the shoreline (see Tables 5 and 6). At higher elevations the tree species varied from a mesic association of basswood, ash, Norway maple, and ironwood to a more xeric association including northern red oak, birch, quacking aspen, red cedar, and white pine. Under the mesic forest the herb layer includes wild ginger, anemone, hepatica, bladder and flowering fern. Near the shoreline more moisture and sunlight are available; thus, goldenrod, asters and columbine may occur near the wild ginger and hepatica, and at the watersedge, red osier dogwood and duckweed.

1 sq = 10'

Bottom type: mu = mud, sa = sand, de = debris, gr = gravel or rocks.
[] = sample plot (quadrat), + = plotless tree sample (point quarter)
≡ = top of bank, b = bottom sampled



1" = 100'

Figure 16. Schematic Diagrams of Riverscape Profiles, Plant and Animal Sampling Locations, and Bottom Types at Each Standard Transect in Lake St. Croix (Gudmundson)

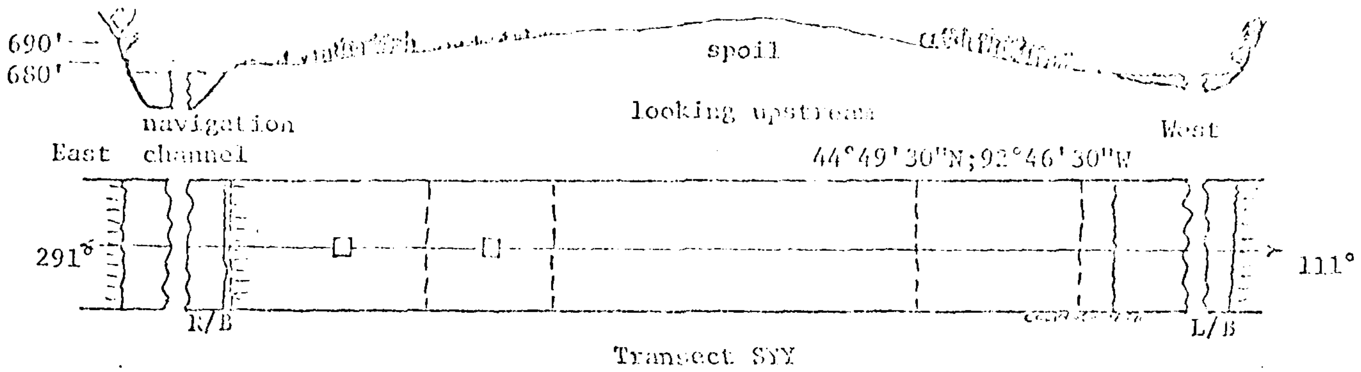


Figure 16 . Schematic Diagrams of Riverscape Profiles, Plant and Animal Sampling Locations, and Bottom Types at Each Standard Transect in St. Croix River (Gudmundson) (Continued)

Table 4. Plant Abundance on Transect SAA, St. Croix River Mile 24.8, 1973 (Colingsworth and Gudmundson)

Species	Left (west) Bank Bluff Area	Right (east) Bank Bank & Floodplain Area
Cyperaceae, sedges		P
Acer saccharinum, silver maple		P
Lemna minor, duckweed		P
Typha spp., cattail		P
Nasturtium officinale, watercress		P
Rumex spp.		P
Impatiens patensis, spotted jewelweed		P
Sambucus canadensis, red-berried elder?		P
Ambrosia artemisiifolia, common rag-weed?		P
Urtica dioica, stinging nettle?		P
Myosotis spp., forget-me-not		P
Equisetum arvense, common horsetail		P
Salix spp., willows (interior)		P
Apocynum spp., dogbane		P
Cerastium vulgatum, mouse-eared chickweed		P
Aster spp., asters	P	P
Moss, moss	P	P
Graminae , grasses	P	P
Ulmus spp., elms	P	P
Salix interior, sandbar willow	P	
Betula papyrifera, paper birch	P	
Fraxinus pennsylvanica var. *subinterrigima*, green ash	P	
Tilia americana, basswood	P	
Acer platanoides, Norway maple	P	
Taxus canadensis, yew	P	
Thalictrum spp., meadow rue	P	
Anemone spp., anemones	P	
Cystopteris fragilis, bladder fern	P	
Asarum canadense, wild ginger	P	
Aquilegia canadensis, columbine	P	
Solidago spp., goldenrods	P	

Table 5. Plant Occurrence on Transect SYY, St. Croix River Mile 6.4, 1973 (Colingsworth and Gudmundson)

Species	Left (east) Bank: Shore-line	Left (east) Bank: Quad. #1	Left (east) Bank: Quad. #2	Left (east) Bank: Bluff Slope	Right (west) Bank: Bluff Slope
Potentilla spp., cinquefoil		1%			
Graminae, grasses		10%			
Unknown #1		1%			
Compositae, unknown		1%			
Taraxacum spp., dandelions		1%		P	
Solidago spp., goldenrods		5%			P
Salix interior & *amygdaloides*, peach-leaved willow & sandbar willow		P	100%		
Vitis spp., grapes		P	P	P	
Agrostis spp., bentgrapes			10%		
Labitae, mints			15%		
Acer saccharinum, river maple		P	P	P	P
Populus deltoides, eastern cottonwood	P		P	P	P
Pinus strobus, white pine				P	
Smilax spp., greenbriar				P	P
Quercus borealis, northern red oak				P	P
Fraxinus spp., ashes				P	
Cornus stolonifera, red osier dogwood				P	
Anemone spp., anemone				P	
Lemna menor, lemma				P	
Ribes spp., gooseberries				P	
Hepatica acutiloba, sharp-lobed hepatica				P	
Cystopteris spp., bladder fern				P	
Carpinus caroliniana, ironwood ?				P	
Cyperaceae, sedges				P	
Mosses, mosses				P	
Juniperis virginiana, red cedar				P	
Ulmus spp., elms				P	P
Betula *papyrifera*, paper birch					P
Elymus canadensis, wild rye					P
Phalaris spp., canary grasses					P
[illegible] spp.					P
Melilotus spp., sweet clover					P
Bare rock & sand			20%		
Leaf litter		100%			

Table 5. Continued

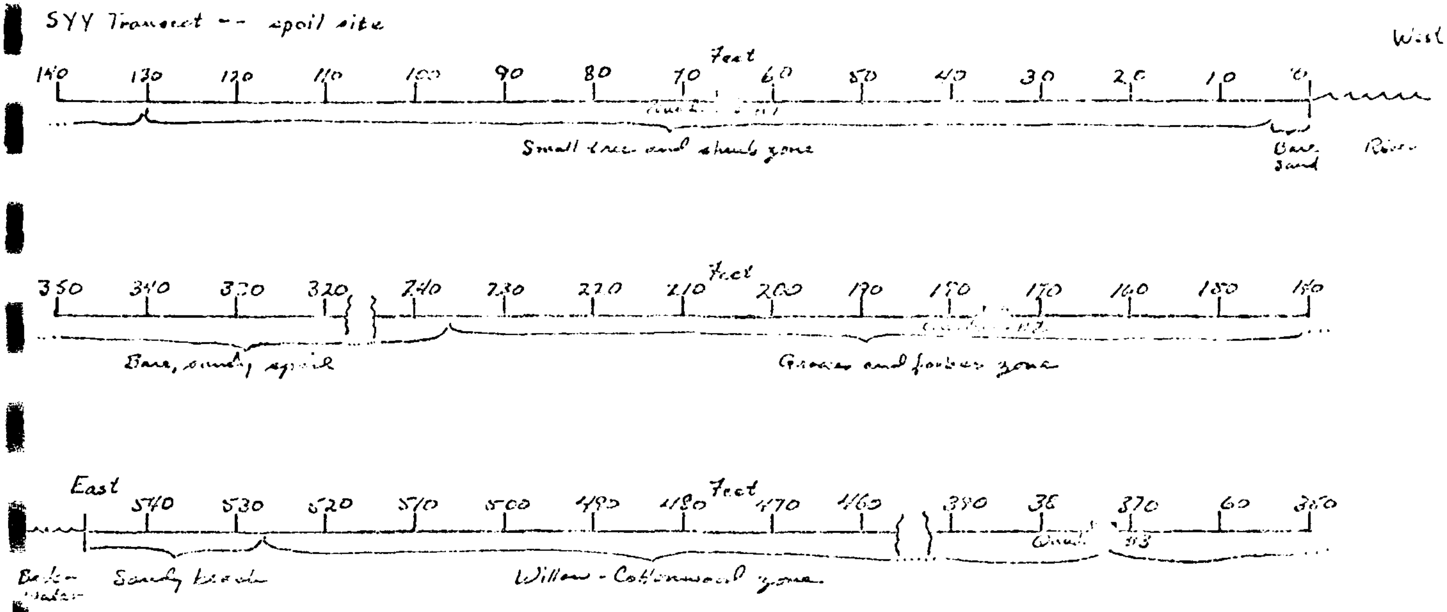


Table 6 . Plant Occurrence on Transect SCC, St. Croix River Mile 0.7, 1973 (*Colingsworth and Gudmundson*)

Species	Left (east) Bank Bluff Slope Area	Right (west) Bank Bluff Slope Area
Populus deltoides, eastern cottonwood	P	
Unknown tree (planted) ?	P	
Hypericum spp., St. Johnswort	P	
Betula spp., birches	P	
Fraxinus spp., ashes	P	P
Ulmus spp., elms		P
Quercus borealis, northern red oak		P
Juniperus virginiana, red cedar		P
Tilia americana, basswood		P
Rhus typhina, staghorn sumac		P
Lonicera sp., honeysuckle		P
Populus tremuloides, quaking aspen		P
Solidago spp., goldenrod		P
Celestrus spp., bittersweet		P
Anemone spp., anemone		P
Taraxacum spp., dandelions		P
Impatiens capensis, spotted jewelweed		P
Aster spp., asters		P
Graminae, grasses		P

The herbs and shrub layer have a very low diversity at the residential areas, left bank of Transects SLE and SCC (see Table 6 and 7).

Cottonwood lines the shoreline on the dredge spoil site, left bank of Transect SYY (see Table 5). Behind the cottonwoods, willow and grape provide shade to grasses, goldenrod, cinquefoil and other forbes. Farther back still willow become very numerous, with river maple and cottonwood and an herb layer consisting of bentgrass, mint, and grape (see Tables 1 and 2, Appendix A IV).

Autumn coloring in the valley is spectacular. Dominated as it is now by a variety of hardwoods, with an intermixing of conifers, the lower St. Croix Valley has become an important fall attraction to thousands of people each September and October to observe, photograph and enjoy the natural display.

Wildlife

The St. Croix River, within the study reach, provides a natural travel lane for wildlife, as well as permanent residences for many game and non-game animals (BOR, 1972). The relatively steep-walled valley is well covered with numerous species of trees, shrubs and herbaceous plants that are highly attractive to a variety of wildlife. Vegetation on the floodplain, riverbank and islands is lush in many portions of the river.

Many different species of waterfowl use the river proper during the annual spring and fall migrations (see Table 2, Appendix A IV). During migration, surface feeding ducks include widgeon, mallard, wood duck, blue and green-winged teal, pintail, gadwall, black duck, and shoveller. Diving ducks, primarily the lesser scaup, ringneck, goldeneye, canvasback, and redhead frequent the river. The valley's breeding ducks are primarily confined to wood duck, mallard, and blue-winged teal.

Table 7. Plant Abundance on Transect SB8, St. Croix River Mile 12.3, 1973 (Collingsworth and Gudmundson)

Species	Right (west) Bank Bluff Area	Left (east) Bank Bluff Area
Impatiens spp., jewelweed	P	
Solidago spp., goldenrod	P	
Panicum spp., panic grass	P	
Rhus typhina, staghorn sumac	P	
Tilia americana, basswood	P	
Fraxinus spp., ashes	P	
Populus deltoides, eastern cottonwood	P	
Vitis spp., grapes	P	
Salix interior, sandbar willow	P	P
Ulmus spp., elms	P	P
Rosa spp., roses, etc.	P	P
Acer saccharinum, silver maple		P
Quercus macrocarpa, burr oak		P
Quercus velutina, black oak		P
Pinus resinosa, red pine		P
Betula spp., birches		P
Cystopteris spp., bladder fern		P
Osmunda spp., flowering ferns		P

Marsh and shorebirds include Wilson's snipe, rails, woodcock, gallinules, and several species of sandpipers. These birds occupy shoreline and lowland habitats along the lower St. Croix.

Great blue herons and American egrets are a prime viewing attraction each fall. Another autumn attraction is the hawk migration along the bluffs. In addition to numerous red-tailed hawks and other broad-winged species, falcons, ospreys, and eagles migrate through the valley. Turkey vultures, gulls and terns may be observed along the river, and the pied-billed grebe and green heron are frequently sighted. The spring and fall migrations of warblers are annual highlights for enthusiastic bird watchers.

Several species of upland game birds inhabit the lower St. Croix Valley. Ruffed grouse are present in limited numbers. Mourning doves are abundant throughout the river valley and are nesting residents. However, they are not a legal game bird in either Minnesota or Wisconsin. A few bobwhite quail and pheasants occur along the valley, principally in association with agricultural lands edging the lower end of the valley.

There have been no specific inventories of the bird and animal life along the lower St. Croix River; however, fairly intensive surveys have been conducted on the lower Kinnickinnic River valley by personnel from the Wisconsin State University-River Falls. Lists of birds and other animals are available for the lower Kinnickinnic River valley (see Tables 2 and 3 in Appendix A IV).

A record was kept of birds, mainly water-oriented, sighted during field studies this summer on the major rivers in the Twin Cities area (Table 8). None of these birds were observed on Lake St. Croix, perhaps partly because of the lack of suitable backwater habitat. The bluff-slope vegetation, however, probably has populations of some of the species seen in the Kinnickinnic River valley studies.

Table 8. Bird Abundance in the River Valleys in the Twin Cities Area Based Upon Casual Observations, 1973.

Bird Species	Flood Plain Lakes		SAF Pools	Pool 1	Pool 2	Minn. R	St. Croix R.	Total No. Individ.
	Minn. R.	Pool 2						
Great blue heron	75	29			13	84		201
Common egret	19	86			8	4		117
American bittern	3							3
Mallard	25	25	90	1	5	20		166
Coot	48	6						54
Wood duck	9	15	18		2	17		61
Pheasant			1					1
Woodpecker			2			1		3
Yellow-shafted flicker			3					3
Crackle			2			1		3
Sparrow			1					1
White-throated sparrow			1					1
Spotted sandpiper			1			19		20
Bank swallow						3		3
Belted kingfisher		1			8	22		31
Black tern						3		3
Teal						2		2
Black duck						1		1
Hooded merganser						1		1
Pied-billed grebe			1					1
Barn swallow			1					1
Osprey		1				2		3
Red-tailed hawk	1							1
Green heron		1			2	38		41
Crow						12		12
Black-crowned night heron					8			8
Common tern		12						12
Canada goose			10			7		17
Total No. individ./pool	180	176	130	1	47	237	0	771

The small mammals inhabiting the lower St. Croix region include shrews, bats, moles, mice, chipmunks, and ground squirrels. These small animals are gaining increasing recognition for their ecological role in the natural system. They serve an important function as buffer species between predators and game birds.

Numerous reptiles and amphibians are native to this area. These include salamanders, toads, frogs, turtles, snakes and skinks. These forms add considerable interest and variety to the area fauna.

The nut-producing trees, principally oak and hickory, provide an excellent food supply for gray squirrels and fox squirrels. Cottontail rabbits are common on the higher ground. Snowshoe hares occur in isolated locations where suitable cover exists. Other species heavily dependent upon woodland habitat include the porcupine, red squirrels, and flying squirrels.

White-tailed deer are common, especially upstream from Stillwater, probably making use of the ravines to gain access to the lake. They have made an excellent comeback along the river since the 1930's, because of the improved protection and management programs of both states.

Muskrats, mink, raccoon, fox and skunks are common along the lower St. Croix, but probably are uncommon in and along Lake St. Croix. Beaver occasionally take up residence in the tributary streams. Otter and oppossum are present but uncommon. Trapping activity is generally very limited.

The diversified fauna of the St. Croix Valley attracts many people to the area. The rich variety of animal life, especially the birds, is caused by several factors. These include the midcontinental location, with overlapping ranges of eastern and western species; climatic conditions in the sheltered valley; and the merging of differing life zones. These factors have enabled a number of southern birds to extend their ranges northward in the valley. Among this group are the Carolina wren, mockingbird, cardinal and several warblers.

Numerous nongame species of wildlife provide aesthetic and intangible values to bird watchers, wildlife photographers, and other outdoor recreationists who find enjoyment in nature's beauty (BOR, 1972).

Water Quality

The water quality of Lake St. Croix appears to be better than that of the Mississippi or the Minnesota Rivers. This better quality may be due to less intensive agricultural and urban development in the St. Croix River watershed.

For instance, th coliform bacteria ranged from 80 to 9200 MPN/l (most probable number per liter) in the St. Croix. The Mississippi River may have over 100,000 MPN/l (FWPCA, 1966).

Recent data show that the dissolved oxygen in the St. Croix varies from 6 to 12 ppm (see Table 4 in Appendix A IV), but the Mississippi frequently has less than 3 ppm (Hokanson, 1968).

Turbidity is also less in the St. Croix ocmpares with the Mississippi downstream from the mouth of the Minnesota River: 1 to 11 JTU (Jackson Turbidity Units) compared with 35 to 60 JTU.

The St. Croix River also has softer water: 50 to 150 ppm alkalinity, whereas the Mississippi River has 100 to 200 ppm and the Minnesota River from 200 to 300 ppm alkalinity (Dawley, 1947).

Augatic Vegetation

Aquatic vegetation is sparse in Lake St. Croix. Periodic high water and floods have resulted in a scoured condition along the shore. This, in combination with the steep and sandy bottom, has discouraged the establishment of most aquatic plants. The most important exceptions are wild celery and river pondweed. In protected backwater areas and sloughs other species of pondweeds, naiads, cattail, coontail, rushes, sedges, arrowhead, bur-reed, watercress and duckweed may appear. However, such areas are generally offstream, such as at the head of the lake just upstream from Stillwater and these plants often go unnoticed by river travelers (BOR, 1972).

Seasonal changes in phytoplankton and periphyton algae abundance have been recorded from the Upper Reach of Lake St. Croix (Stillwater to Hudson, NSP, 1971). These algal communities are composed mainly of four algal groups (divisions), including Cyanophyta (blue-greens), Chlorophyta (greens), Chrysophyta (goldens and diatoms) and Cryptophyta (see Tables 5 and 6, Appendix A IV). Counts indicate each division may have its own seasonal maximum or "bloom". The Chrysophyta and Chlorophyta often bloom in Spring and Fall, while the Cyanophyta are most abundant during the summer.

A period of maximum abundance of attached algae generally occurs in the late summer and a minimum in winter as indicated by chlorophyll "a" concentrations that attached algae which are collected on artifical substrates.

However, local variations in the river may noticably alter community abundance and composition. During summer, the phytoplankton, particularly blue-green algae, may become quite abundant downstream from Hudson, Wisconsin (see Figure 17). This "bloom" of blue-greens produces more dissolved oxygen (see Figure 18).

Where thermal effluents enter the river (Station 3A), blue-green algae dominate the attached algal community compared with the upstream control (Station 3 in Figure 19).

In winter ice-free areas occur where thermal effluents, storm sewers, and springs enter the river, and where the river becomes narrow and shallow. The limitation of light upon algal growth is removed in these ice-free areas. Thus attached algae may occur in abundance as shown by chlorophyll "a" concentrations near a thermal effluent (Station 3A in Figure 20).

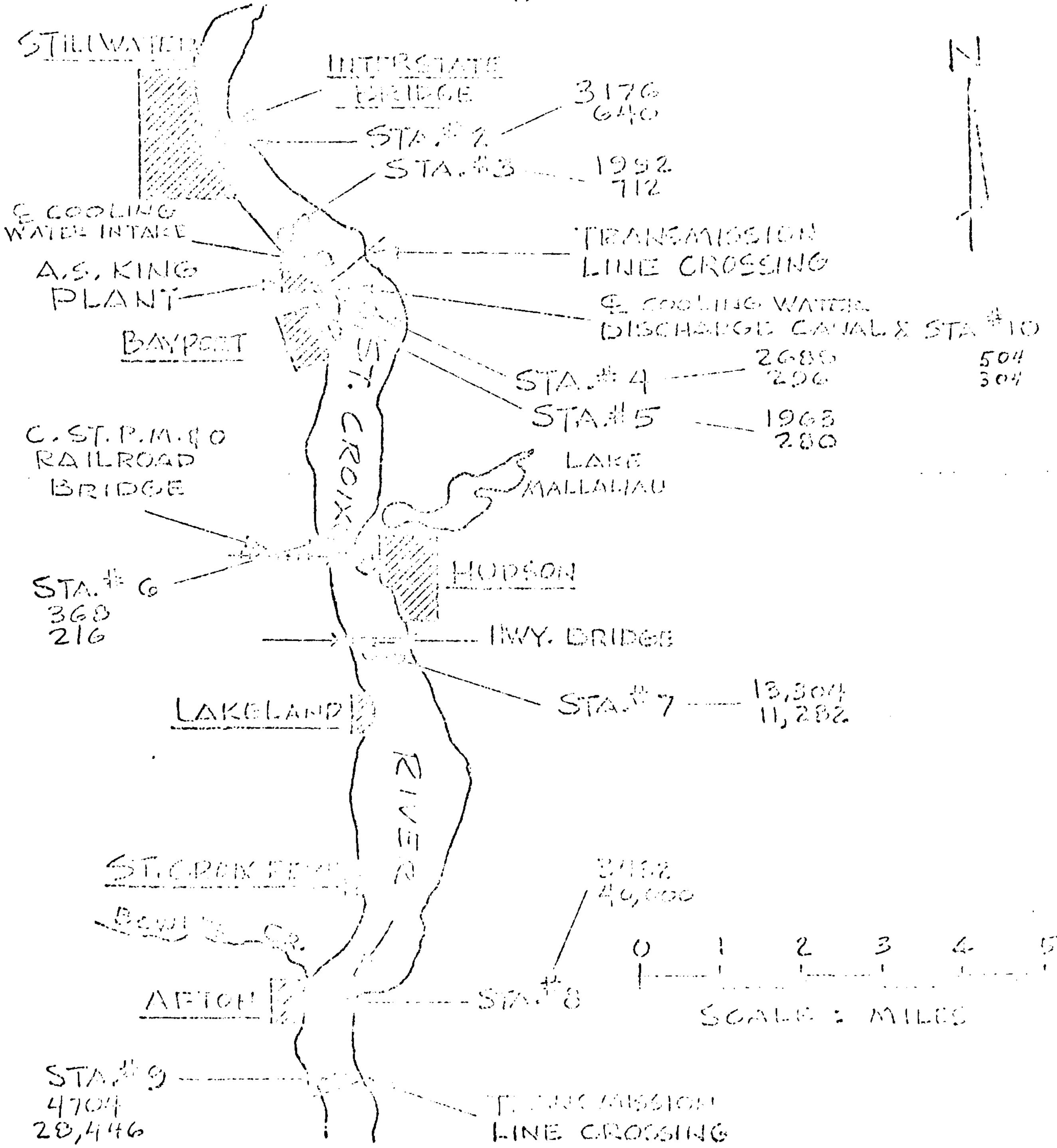


Figure 17. Downstream pattern of Blue-Green Phytoplankton Abundance in Lake St. Croix on July 1 (upper number at each station) and on August 27 (lower number) 1970 (NSP, 1970)

26 Aug 70

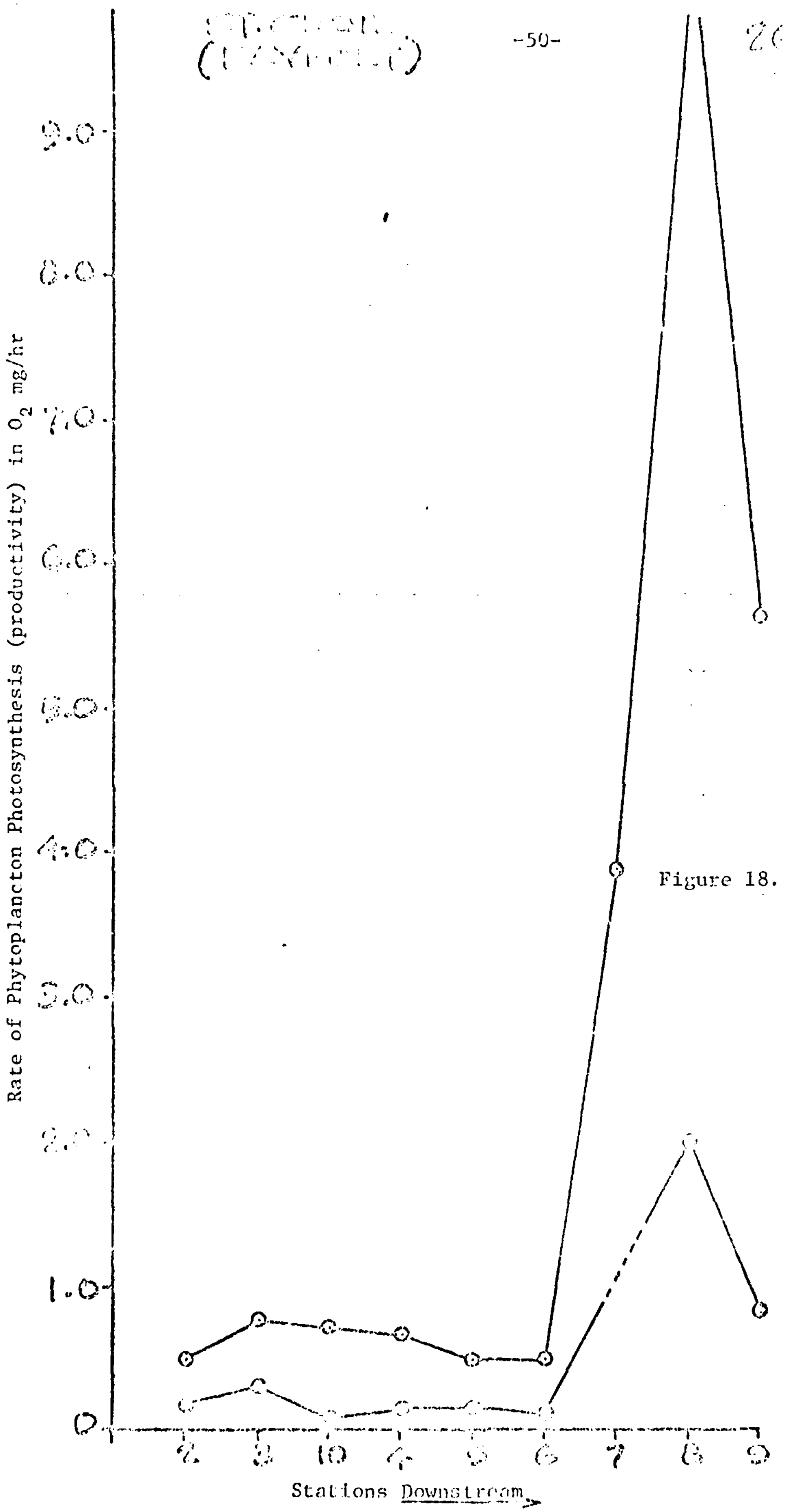


Figure 18. Rate of Phytoplancton Photosynthesis (productivity), in O_2 mg/hr, in Lake St. Croix from Stillwater (Station 2) to Downstream from Afton on August 26, 1970. (NSP, 1970)
Note: King Plant shut down 24-28 hours previously, but circulating pump "on". See previous figure for station location.

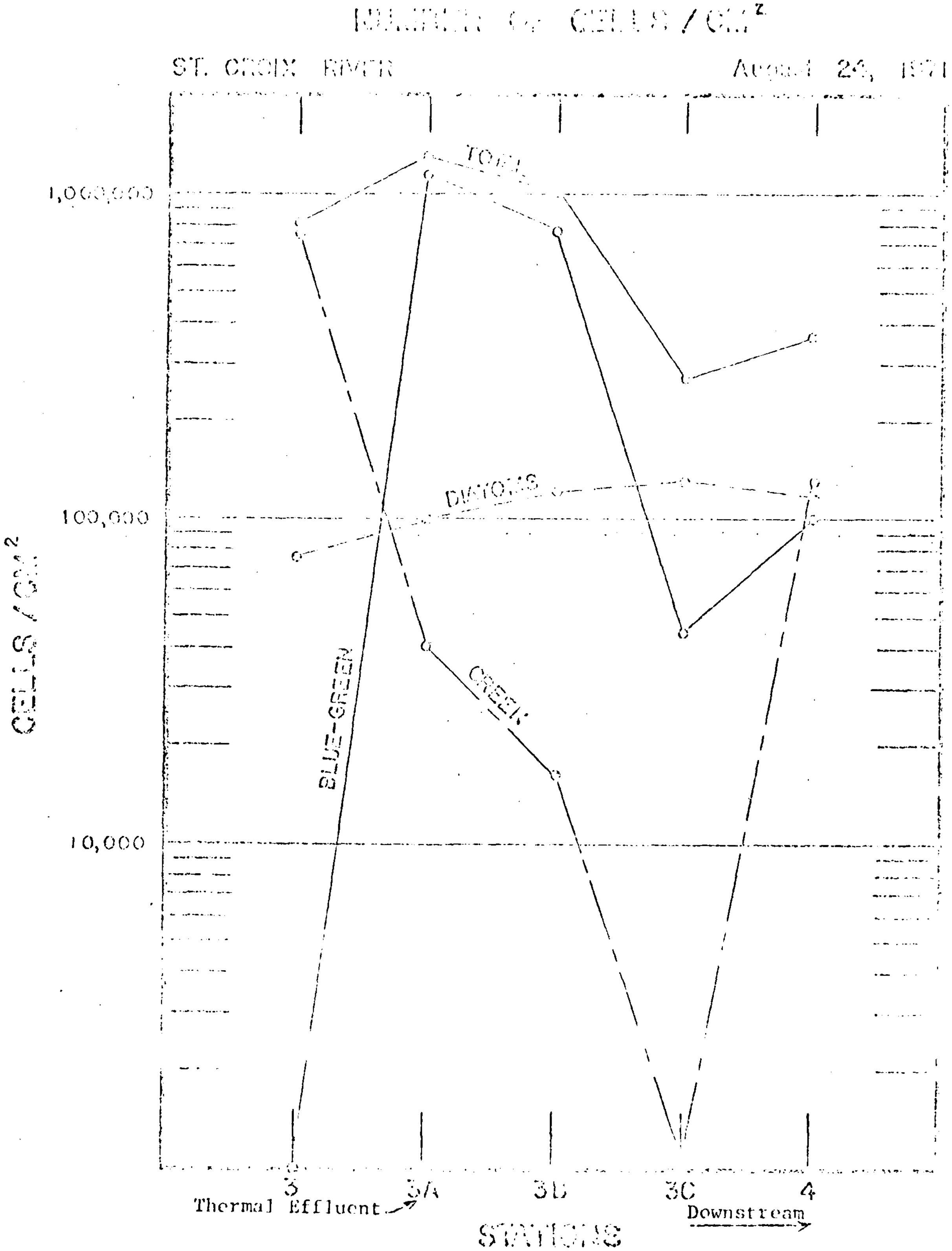


Figure 19. The Effect of Thermal Effluent from NSP's King Plant (Station 3A) Upon the Composition of the Attached Algal Community in Lake St. Croix (NSP, 1971) Note: See Figure 19A for station locations.

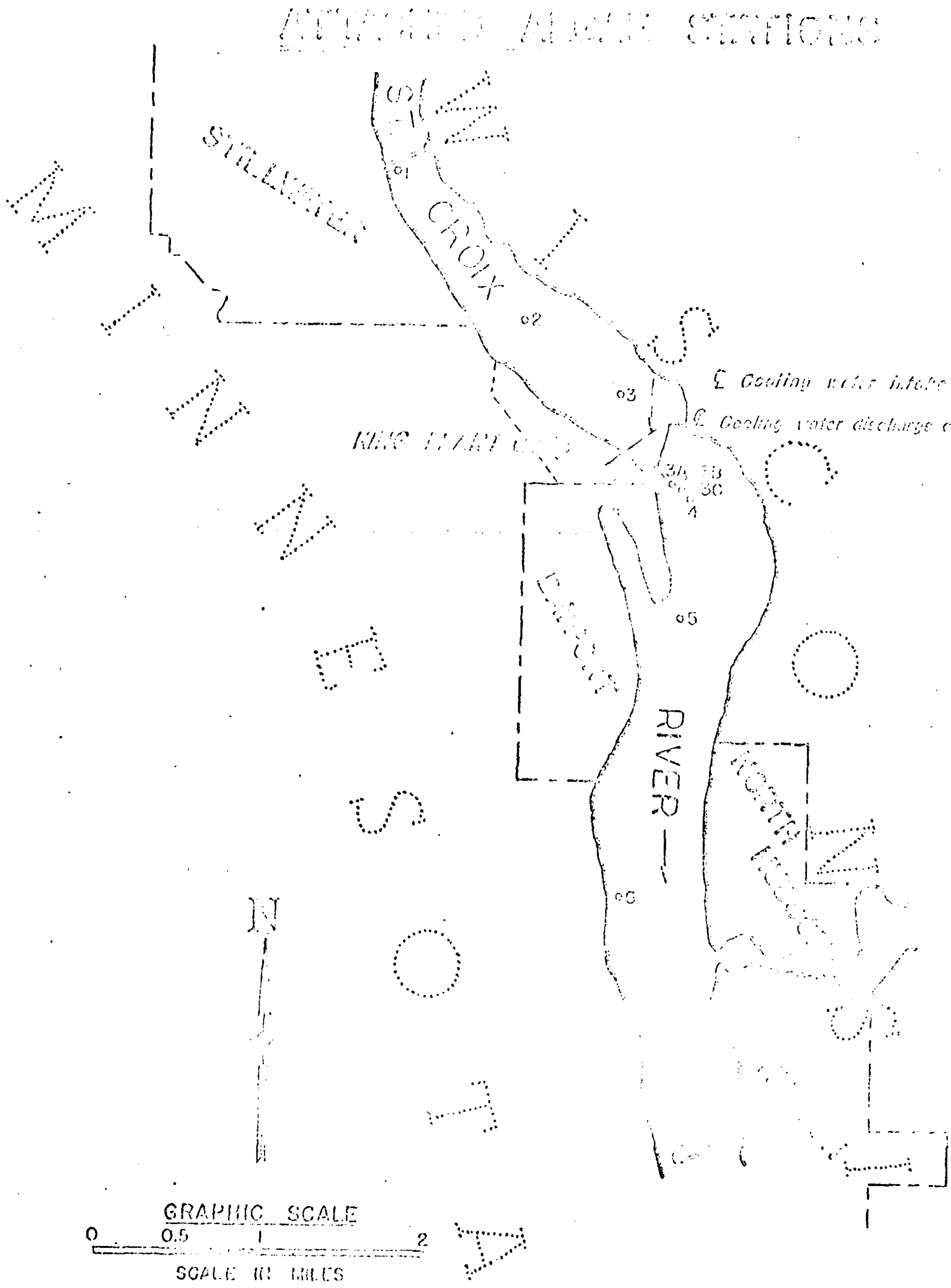


Figure 19A. Location of Stations for Attached Algae Studies on Lake St. Croix (NSP, 1971)

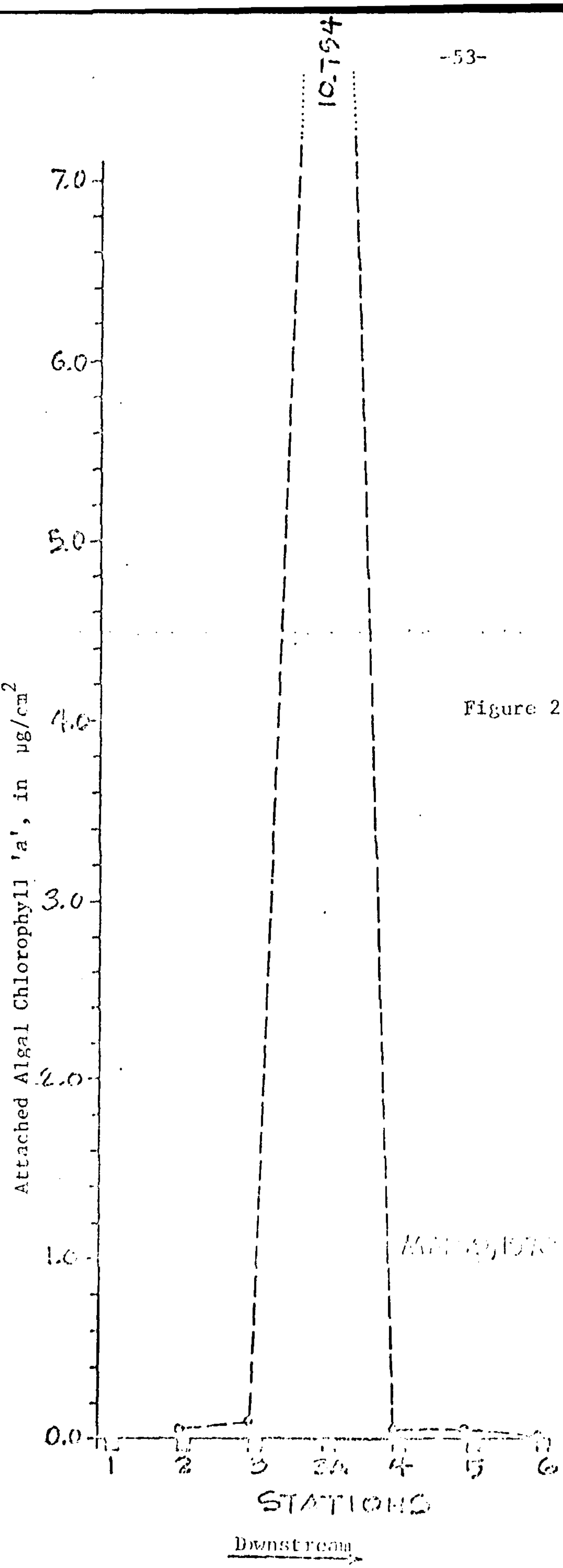


Figure 20. Abundance of Attached Algae, Indicated by Chlorophyll 'a' Concentration, in the Ice-Free Area at NSP's King Plant (Station 3A) (NSP, 1970)

Aquatic Animals

Of the 120 species of fish reported from the Upper Mississippi River Basin (FWS, 1970), 62 species have been reported from Lake St. Croix (see Table 14 in Appendix A IV). Thirteen common game fish and eleven common rough fish species have been reported from the St. Croix River (see Tables 9 and 10). By comparison, the St. Croix has 30 percent more game fish species than the next most abundant area, the reach of the Minnesota from Shakopee to Mankato. The same number of rough fish species was found in the St. Croix as in Pools 2 and 3 of the Mississippi.

Sport fishing is generally concentrated on sauger, walleye, and panfish in the lake (see Table 15, Appendix A IV), while smallmouth bass are more sought after in the upper reaches above Stillwater. Northern pike are occasionally taken throughout the study area. Above Stillwater muskies are taken, though rarely. Near Hudson rainbow trout are occasionally caught, mainly incidental to other fishing.

Fish netting samples taken in 1970 in the Kinnickinnic River listed ten different species. Listed in their order of abundance are shiners, longnose dace, white sucker, creek chub, shortnose dace, log perch, bluntnose minnow, carp, Johnny darter, and green sunfish. This sampling of the Kinnickinnic River should give an indication of the species composition in the other tributary streams.

The fish species normally harvested commercially are the carp, buffalofish, catfish, sheepshead, and suckers. Quillback, redhorse, and occasionally, eels are also taken. Other major predatory or forage fish include the dogfish, mooneye, gizzard shad, gar, log perch, and burbot. In addition, two species present but considered uncommon are the shovelnose sturgeon and paddlefish. The lake sturgeon, a threatened species, is also present (BOR, 1972).

Table 9. Common Species of Game Fish in the Large Rivers of the Twin Cities Metropolitan Area (MWPCA, 1966).

Species	Mississippi River: Rum River To St. Anth. Falls	Mississippi River: Pool No. 1	Mississippi River: Pool No. 2	Mississippi River: Pool No. 3	Minnesota River: River Mile 70 to 25	Minnesota River: River Mile 25 to 0	St. Croix River
Walleyed Pike	X	(list is incomplete)	X	X	X		X
Sauger			X	X	X		X
Northern Pike	X		X	X	X		X
Black Crappie	X		X	X	X	X	X
White Crappie				X	X	X	
Largemouth Bass			X		X		
Smallmouth Bass	X	X			X		X
Rock Bass	X		X				X
White Bass				X	X		X
Bluegill	X		X	X			X
Channel Catfish			X	X	X	X	X
Sturgeon							X
Flathead Catfish				X	X	X	X
Green Sunfish			X				
Pumpkinseed	X						X
Brown Trout							X
Number of Species	7	-	9	9	10	4	13

Note: This is not necessarily a complete list.

Table 10. Common Species of Rough Fish in the Large Rivers of the Twin Cities Metropolitan Area (FWPCA, 1966).

	Mississippi River				Minnesota River		
	Rum River to St. Anthony Falls	Pool No. 1	Pool No. 2	Pool No. 3	River Mile 70 to 25	River Mile 25 to 0	St. Croix River
Carp	X	X	X	X	X	X	X
Quillback					X		X
Sheepshead		X	X	X		X	X
Brown Bullhead							X
Bigmouth Buffalofish	X		X	X	X	X	X
Northern Carpsucker				X	X	X	
Northern Redhorse	X	X	X	X	X		X
Longnose Gar				X			X
Shortnose Gar			X	X	X	X	X
Bowfin			X				
Mooneye			X	X			X
Gizzard Shad			X	X	X	X	
Common Sucker	X	(List is incomplete)	X	X	X	X	X
Spotted Sucker							
Yellow Bullhead	X						
Black Bullhead	X						
Golden Shiner				X			
Perch			X				X
River Sucker			X				
Number of Species	6	--	11	11	8	7	11

Note: This is not necessarily a complete list.

Thirty-two minnows and darters have been reported from the St. Croix River watershed, compared with 57 from the "Lower" (downstream from St.Anthony Falls) Mississippi River watershed (see Table 11).

Bottom sediments are uniform throughout the lake and consist mostly of a mixture of sand and organic sludge in 1964 (see Figure 21). The 1973 samples contained mainly sand and some gravel in the main channel. However, a gellatinous mud with a layer of fine silt occurred in the main channel near the mouth of the St. Croix. The sediments in the backwaters consisted of fine sand and silt.

A comparison of the data on benthic organisms collected this summer shows that the most abundant populations were collected near the mouth of the Kinnickinnic River (Transect SYY, see Table 12 & 13 and Figure 22). On this Transect, the chironomids were most abundant in the quiet backwaters, while a larger population of oligochoctes was found in mid-channel. The most frequent dredging of the St. Croix occurs at the confluence of the Kinnickinnic River (Figure 1 in Appendix A IV).

At the other stations, the abundance of benthic organisms was very low (Table 12 in Appendix A IV). Snails and clams were found only at Hudson, Wisconsin (Transect SXX).

Twelve benthic organisms new to the record for the St. Croix River were found during the summer field studies, 1973.

Table 11. Minnows and Darters in Sections of the Upper Mississippi River Watershed (Underhill, 1957)

Species	Mississippi River		St. Croix	Minnesota
	Lower	Upper		
Catostomidae				
Hypentelium nigricans	X		X	X
Cyprinidae				
Notemigonus crysoleucas	X	X	X	X
Semotilus atromaculatus	X	X	X	X
Semotilus margarita nachtriebi	X	X	X	X
Gila elongata	X			
Opsopoeodus emiliae	X			
Chrosomus neogaeus	X*			
Chrosomus erythrogaster	X			
Chrosomus eos	X	X	X	X
Hybopsis plumbea				
Hybopsis biguttata	X	X	X	X
Hybopsis storeriana	X			X
Hybopsis sp.	X			
Rhinichthys atratulus	X	X	X	X
Rhinichthys cataractae	X	X	X	X
Phenacobius mirabilis	X			
Notropis atherinoides	X	X	X	X
Notropis percobromus	?			
Notropis [illegible]	X			X
Notropis umbratilis	X			
Notropis cornutus	X	X	X	X
Notropis [illegible]	X		X	X
Notropis heterodon	X	X	X*	X
Notropis hudsonius	X	X	X	X
Notropis blennius	X	X	X	X
Notropis dorsalis	X	X	X	X
Notropis amnis	X		X	
Notropis spilopterus	X	X	X	X
Notropis lutrensis	X			
Notropis topeka	X*			
Notropis deliciosus	X	X	X	X
Notropis heterolepis	X	X	X*	X*
Notropis anogenus	X		X	?
Notropis volucellus	X	X	X*	X
Notropis buchanani	X			
Dionda nubila	X		X*	
Hybognathus hankinsoni	X	X	X	X
Hybognathus nuchalis	X			
Pimephales vigilax perspicuus	X*			
Pimephales notatus	X	X	X	X
Pimephales promelas	X	X	X	X
Campostoma anomalum	X	X		X
[illegible]				
Noturus [illegible]	X		X	X
Percidae (Subfamily Etheostominae)				
Percina caprodes	X			X
Percina phoxocephala	X		X	X
Percina [illegible]	X	X	X	X
Percina [illegible]	X		X	
Percina shumardi	X			
Ammocrypta asprella	X*			
Ammocrypta clara	X			X*
Etheostoma nigrum	X	X	X	X
Etheostoma zonale	X			X
Etheostoma chlorosomum	X			
Etheostoma aspirgene	X			X
Etheostoma caeruleum	X			X
Etheostoma exile	X	X	X	X
Etheostoma flabellare lineolatum	X			X
Etheostoma microperca	X*	X	X*	

* Literature record.

Total No. Species	57	25	32	36

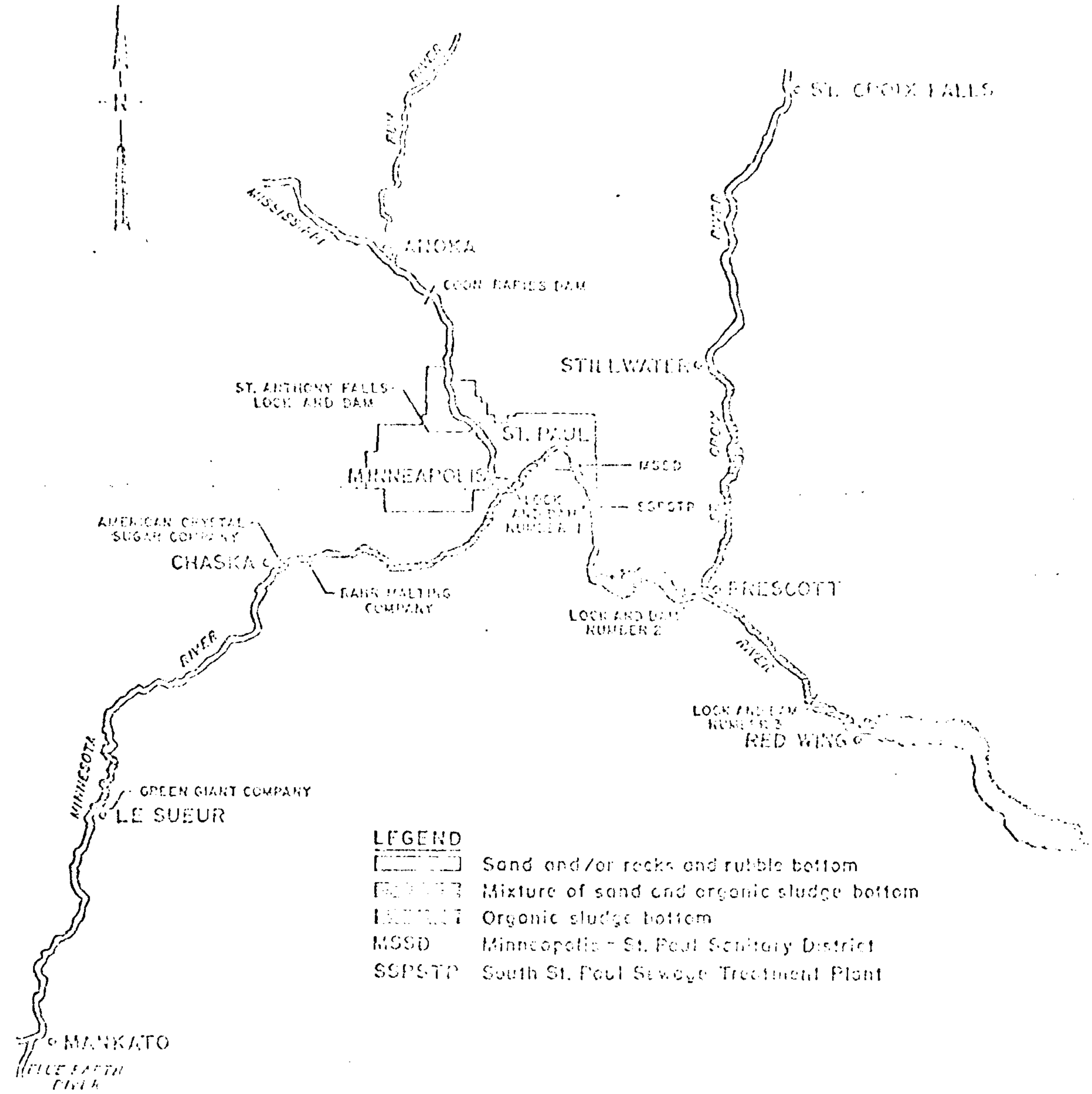


Figure 21. Distribution of Bottom Sediments
(FWPCA, 1966)

Table 12. Abundance of Benthic Organisms (in numbers/sq ft) in Lake St. Croix, 1973.

		Trans. SAA			Trans. SXX			Trans. SXB			Trans. SYY			Trans. SCC	
	L B	Mid-Chan	R B	L B	Mid-Chan	R B	L B	Mid-Chan	R B	L B	Mid-Chan	R B	L B	Mid-Chan	R B
DIPTERA (Flies)															
Chironomidae		3	2	2	3				2	44	2	3			
Tipulidae		1													
Ceratopogonidae		1								2	1				
Chaoboridae				1											
EPHEMEROPTERA (Mayflies)															
Caenidae				1											
ODONOTA (Dragonflies)															
Gomphidae											1				
COLEOPTERA (Beetles)															
Elmidae											1		1		1
OLIGOCHAETA (Earthworms, sludge worms)	1	1		1	1				1	2	62			1	
PELECYPODA (Clams)					5										
GASTROPODA (Snails)					1										
NEMERTEA (Proboscis worms)														1	
NEMATODA (Round worms)									1						
Average no. organisms/sq ft		3			5			1			39			1	

Table 13. Benthic Organisms Not Recorded Previously from the St. Croix River.

CHIRONOMIDAE (midges)		CERATOPOGONIDAE (biting midges)	NEMERTEA (proboscis worms)
Micropsectra	Paracladopelma	Palpomyia	
Procladius	Paratendipes		
Potthastia	Psectrotanypus	GASTROPODA (snails)	
Chaetocladius	Harnischia	Stagnicola	
	Glyptotendipes		

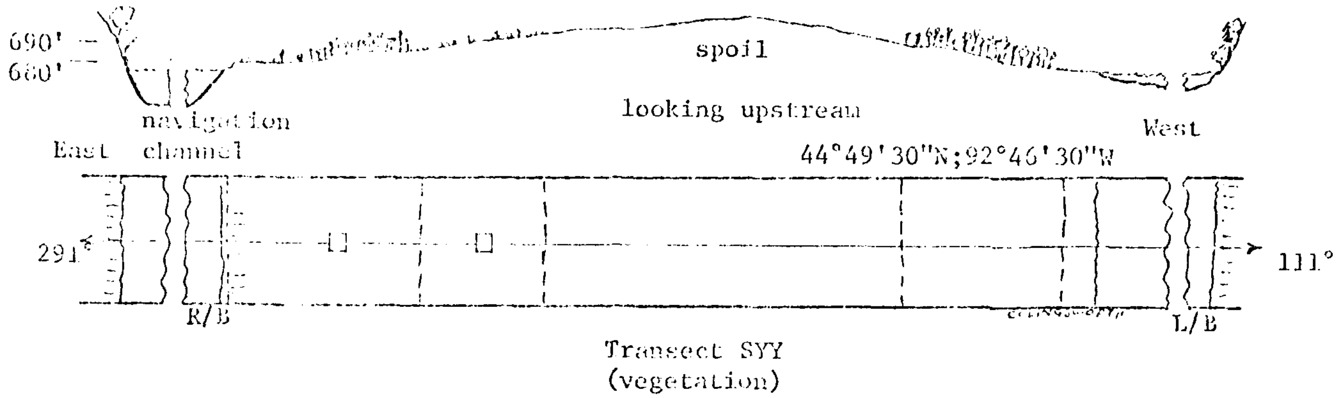


Figure 22. Schematic Diagrams of Riverscape Profiles, Plant and Animal Sampling Locations, and Bottom Types at Each Standard Transect in St. Croix River (Gudmundson)

A study of Minnesota mussels (clams) published 26 years ago showed that 33 species of the 44 reported from the state were found in the St. Croix River (see Table 14). Of these 33 species, 6 have been found recently in the Upper Reach of the lake as have 9 species of snails.

One of the mussels found in the earlier study Lampsilis higginsi, was formerly widespread in the St. Croix, Minnesota and Mississippi (below the Twin Cities) Rivers. However, only one live specimen has been found since 1932, in the Mississippi River at Oquaqua, Illinois, in 1966, and thus the species is considered rare and endangered (now termed threatened) (Imlay, 1972). Several individuals have since been collected in Lake St. Croix at Hudson, Wisconsin (Krosch, 1973). This same area is one of three in the lake which requires dredging (see Figure 1 in Appendix A IV).

Threatened Species

Several lists of threatened plant and animal species have been compiled. ("Threatened" is now the preferred designation of "rare and endangered" species, by the U.S. Fish and Wildlife Service.)

These lists of threatened species include species protected legally or other nonprotected species whose populations are known to be or are suspected of being dangerously low, either locally or nationally. Species rare locally but not in adjacent states, i.e., species at the limit of their geographic range, are included in some lists. This inclusion serves to encourage maintenance of a broad genetic (breeding) pool to help ensure survival of the whole species population. The inclusion of these species also serves to encourage the maintenance of a broad diversity of plants and animals for Minnesotans to enjoy.

The variety of lists of threatened species is due to two difficulties which are encountered in compiling such a list. The first difficulty is the

Table 14. Distribution of Mussels in the Large Rivers near the Twin Cities (Dawley, 1947).

	Mississippi R. below Minneapolis	Mississippi R. above Minneapolis	St. Croix R.	Minnesota R.
1. *Fusconaia undata*	X		X	X
2. *Fusconaia ebenus*	X			
3. *Fusconaia flava*			X	
4. *Megalonaias gigantea*	X		X	X
5. *Amblema peruviana*	X		X	X
6. *Amblema rariplicata*	X			X
7. *Amblema costata*	X		X	
8. *Quadrula quadrula*	X			X
9. *Quadrula pustulosa*	X		X	X
10. *Quadrula metanevra*	X			
11. *Tritogonia verrucosa*	X		X	X
12. *Cyclonaias tuberculata*	X		X	
13. *Plethobasus cyphyus*	X		X	X
14. *Pleurobema cordatum coccineum*	X		X	X
15. *Elliptio dilatatus*	X		X	X
16. *Elliptio complanatus*				
17. *Elliptio crassidens*	X			X
18. *Lasmigona compressa*		X	X	
19. *Lasmigona costata*	X		X	X
20. *Lasmigona complanata*	X		X	X
21. *Anodonta grandis*	X	X	X	X
22. *Anodonta marginata*		X		
23. *Anodonta gigantea*	X			X
24. *Anodonta corpulenta*	X		X	X
25. *Utterbackia imbecillis*	X	X	X	X
26. *Anodontoides ferussacianus*		X	X	X
27. *Alasmidonta marginata truncata*	X		X	X
28. *Arcidens confragosus*	X			X
29. *Strophitus rugosus*	X		X	
30. *Obliquaria reflexa*	X		X	X
31. *Obovaria olivaria*	X		X	X
32. *Actinonaias carinata*	X	X	X	X
33. *Truncilla truncata*	X		X	X
34. *Truncilla donaciformis*	X			X
35. *Plagiola lineolata*	X			X
36. *Leptodea fragilis*	X		X	X
37. *Proptera alata megaptera*	X		X	X
38. *Proptera l[illegible]*	X		X	X
39. [illegible]	X		X	X
40. *L[illegible] latissima*	X	X		X
41. *Lamp[illegible]*				X
42. *L[illegible]*	X	X	X	X
43. *L[illegible]*	X	X	X	X
44. *L[illegible]*	X		X	X

Total No. Species: 39 9 33 35

definition of a threatened species; i.e., at what population size and survival rate (birth rate versus death rate) does a species population become in danger of extinction. Secondly, there is a lack of specific information on the current population size and breeding success of many species.

One threatened species was found during the present study: *Taxus canadensis* (yew), a shruby evergreen (see Table 15). Two other species, the lake sturgeon and the clam *Lampsilis higginsi*, have been reported from Lake St. Croix.

A study of plants from Taylors Falls to Prescott (BOR, 1972) found two legally protected plants in the St. Croix Valley: turk's-cap-lily, bittersweet and trillium. The same study reported one species which is threatened: the prairie phlox, and three plants rare in Minnesota but more or less abundant in adjacent regions: quising, besseya, and the narrow-leaved vervian.

Table 15. Threatened Plants and Animals of the St. Croix River and Kinnickinnic River Valley

Species	
Threatened	
Acipencer fulvescens	Lake sturgeon
Lampsilis higginsi	
Taxus canadensis	Yew
Phlox pilosa	Prairie phlox
Legally Protected	
Lilium superbum	Turk's-cap-lily
Trillium spp.	Trillium
Celastrus scandens	Bittersweet
Plants Rare Only in Minnesota	
Panax quinquefolia	Ginseng
Besseya bullii	Besseya
Verbena simplex	Narrow-leaved vervian

A thorough study should be conducted to determine if other threatened species, included in the lists below, are present in Lake St. Croix Valley.

Plants. A list of rare and endangered plants in Minnesota was compiled by the Minnesota Department of Natural Resources (MDNR, 1971). This list contains a total of ten plant species, including five plants found in moist prairies, three plants found in open hardwoods, and two plants found in the northern conifer forests (see Table 16).

Morley (1972) compiled an extensive list of threatened plant species in several categories. His list of plants legally protected in Minnesota includes all species of the orchid family; all species of lily, trillium and gentian; and trailing arbutus (see Table 17).

A second category in Morley's list included those plants rare in Minnesota and all of North America: a total of four plants. One of these species, the Minnesota trout-lily or adder's tongue, is found nowhere else but in Minnesota.

Morley included a third category containing 252 plants which are rare in Minnesota but are more or less abundant in adjacent regions. A total of 36 of these species are found in one or more of the following metropolitan counties: Hennepin, Ramsey, Washington, Dakota and Scott (Table 18).

Morley's fourth category includes those plants typical of our native grasslands. This list includes 122 plant species. The native grassland habitation is the "most poorly represented (in the University Herbarium) and in greatest danger of eradication in the state". A more detailed study is urgently needed to determine if the drier portions of the spoil banks do harbor these threatened plants, or if not, then to determine the potential of the spoil sites to provide a refuge for native grassland plants.

Wisconsin DNR lists nine plants as legally protected, including trillium, wood lily, turk's-cap-lily, pitcher plant, purple-fringed orchid, ladyslipper, trailing arbutus, bittersweet, and American lotus (WIDNR, 1970).

Table 16. Rare and Endangered Plants of Minnesota
(MN Department of Natural Resources, 1971)

	<u>Moist Prairie Habitat</u>
Moist meadows	Wild orange-red lily, wood lily, <u>Lilium philadelphicum</u>
	Shooting star, <u>Dodecatheon meadia</u>
	Small white lady's-slipper, <u>Cypripedium candidum</u> (orchid)
	Prairie phlox, <u>Phlox pilosa</u>
	Blue-eyed grass, <u>Sisyrinchium angustifolium</u>
	<u>Grazing in Hardwoods in the Southeast</u>
Fairly open hardwoods	Bluebell, Virginia cowslip or Lungwort, <u>Mertensia virginica</u>
	*Minnesota trout-lily, <u>Erythronium propullans</u>
	*Adam-and-Eve root, <u>Aplectrum hyemale</u> (orchid)
	<u>Northern Forest</u>
Fairly open coniferous forests	Yew, <u>Taxus canadensis</u>
	Ram's-head lady's-slipper, <u>Cypripedium arietinum</u> (orchid)

*has always been fairly rare

Table 17. Rare or endangered plants of Minnesota with the counties in which they have been found (Nature Conservancy -Morley 1972)

<u>Plants rare in Minnesota and in all of North America</u>

Cruciferae; Mustard Family
Draba norvegica, Whitlow-grass: Cook.

Leguminosae; Pea Family
Lespedeza leptostachya, Prairie Bush-clover: Cottonwood, Crow Wing, Goodhue.

Liliaceae; Lily Family
Erythronium propullans, Dwarf or Minnesota Trout-lily or Adder's Tongue: Goodhue, Rice. Found nowhere else in the world.

Orchidaceae; Orchid Family
Malaxis paludosa, Bog Adder's Mouth: Clearwater, Ottertail.

<u>Plants legally protected in Minnesota</u> (the protection is weak, and needs strengthening).

Ericaceae; Heath Family
Epigaea repens, Trailing Arbutus.

Gentianaceae; Gentian Family
Gentiana, Gentian, all species.

Liliaceae; Lily Family
Lilium, Lily, all species
Trillium, trillium, all species.

Nymphaeaceae; Water Lily Family
Nelumbo lutea, Lotus Lily.

Orchidaceae; Orchid Family
All Species.

Table 18. Plants Rare in Minnesota but More or Less Abundant in Adjacent Regions (Morley, 1972).

PLANTS	FOUND IN (COUNTY)
Angiosperms: Flowering Plants	
Alismataceae; Water Plantain family	
Sagittaria graminea, grass-leaved arrowhead	Ramsey, Washington, St. Louis
Araceae; Arum family	
Arisaema dracontium, Green dragon, dragon root	Dakota, Winona, Houston
Araliaceae; Ginseng family	
Panax quinquefolius, ginseng	Once widespread from Houston to Jackson to Mille Lacs to Washington Counties, now nearly exterminated by herb hunters
Campanulaceae; Bluebell family	
Specularia leptocarpa, western Venus' looking-glass	Ramsey
Caryophyllaceae; Pink family	
Stellaria alsine, chickweed	Ramsey, Winona
Cistaceae; Rock-rose family	
Helianthemum canadense, frostweed	Fillmore, Houston, Winona, Washington
Compositae; Sunflower family	
Coreopsis tinctoria, golden coreopsis	Blue Earth, Hennepin, Ramsey
Convolvulaceae; Morning-glory family	
Cuscuta polygonorum, smartweed dodder	Freeborn, Hennepin
Cruciferae; Mustard family	
Arabis laevigata, smooth rock cress	Clearwater, Todd, Hennepin, Houston
Cyperaceae; Sedge family	
Carex formosa	Ramsey
Carex plantaginea	Hennepin, Winona
Scleria triglomerata, tall nut-rush	Anoka, Hennepin, Ramsey
Scleria verticillata, low nut-rush	Blue Earth, Dakota, Hennepin, Scott
Droseraceae; Sundew family	
Drosera linearis, slender-leaved sundew	Hennepin
Gramineae; Grass family	
Echinochloa walteri, cockspur grass	Wabasha, Washington
Juncaceae; Rush family	
Juncus articulatus, jointed rush	Ramsey

Table 18 (Continued).

PLANTS	FOUND IN (COUNTY)
Angiosperms; Flowering Plants	
Leguminosae; Pea family	
Astragalus ceramicus, rattle-pod	Ramsey
Lythraceae; Loosestrife family	
Decodon verticillatus, swamp loosestrife	Anoka, Chisago, Hennepin
Najadaceae; Naiad family	
Najas olivacea, bright-green naiad	Anoka, Ramsey
Onagraceae; Evening primrose family	
Gaura biennis, biennial gaura	Hennepin Houston
Potamogetonaceae; Pondweed family	
Potamogeton diversifolius, Rafinesque's pondweed	Anoka, Ramsey
Rosaceae; Rose family	
Rubus folioflorus, blackberry	Ramsey, Washington, St. Louis
Rubus latifoliolus, blackberry	Isanti, Ramsey
Rubus rosendahlii, Rosendahl's blackberry	Ramsey
Rubus semisetosus, blackberry	Anoka, Ramsey
Rubiaceae; Madder family	
Galium verum, yellow bedstraw	Hennepin, Lac Qui Parle, St. Louis
Scrophulariaceae; Figwort family	
Aureolaria pedicularia, false foxglove	Hennepin, Washington, Houston
Besseya bullii, besseya	Dakota, Goodhue, Hennepin, Ramsey, Scott, Washington
Gerardia auriculata, auricled gerardia	Blue Earth, Dakota, Nicollet
Gerardia gattingeri, Gattinger's gerardia	Nicollet, Wabasha, Winona, Washington
Gerardia purpurea, large purple gerardia	Hennepin
Solanaceae; Potato family	
Solanum triflorum, cut-leaved nightshade	Clay, Hennepin
Umbelliferae; Parsley family	
Hydrocotyle americana, American marsh pennywort	Chisago, Washington, Houston
Verbenaceae; Vervain family	
Verbena simplex, narrow-leaved vervain	Fillmore, Rock, Scott
Xyridaceae; Yellow-eyed grass family	
Xyris torta, slender yellow-eyed grass	Anoka, Hennepin

Barthelemy (1971) includes three plant species in his list: two cacti and a legume (see Table 19).

Animals. Barthelemy's (1971) list includes 36 rare and endangered animals, including three reptiles and amphibians, one mammal and 29 birds. Of these, the sandhill crane, osprey and American (common) egret occur in the Twin Cities area, although apparently they are not visitors of Lake St. Croix.

The list of rare and endangered species compiled by the U.S. Fish and Wildlife Service (1970) includes two mammals, four birds and one fish (Table 20). This fish, the Lake sturgeon, has been netted in the St. Croix River by the MDNR, and occasionally one is caught by an angler.

One species of clam, _Lampsilis higginsi_, is a threatened species (Imlay, 1972) and is reported from the Hudson, Wisconsin, area of Lake St. Croix (Krosch, 1973).

Pre-Project Vegetation

A second growth mixed conifer-hardwood forest replaced the pine forest which was cut for lumber in the late 19th century. Although no information is available, this mixed forest probably covered the blufftops and now vestiges may remain on bluff slopes. Southwestern exposures may still support prairie remnants, such as the grassy slope with scattered cedars on the Wisconsin bank at Mile 20. A large willow and brush swamp and a wild rice bed of about [illegible] acres were submerged by the impoundment of Lake St. Croix.

Table 19. Rare and endangered reptiles, mammals plants, and birds in Minnesota (R. E. Barthelemy, 1971)

<u>Reptiles</u>

Blue tailed Skink

Wood Turtle

Blanding's Turtle

Cricket Frog

Red-backed Salamander

Common Newt

<u>Mammals</u>

Star-nosed Mole

<u>Plants</u>

<u>Lotus americana</u> birdsfoot-trefoil

<u>Mammilaria</u>

<u>Opuntia raffinesquii</u> cactus

<u>Birds</u>

Sprague's Pipit

Baird's Sparrow

Yellow Rail

White Pelican

1. egret (American)
2. cattle
3. snowy

<u>Birds continued</u>

Trumpeter Swan

Bald Eagle

Osprey

Peregrine Falcon

Marsh Hawk

Sandhill Crane

Piping Plover

Wilson's Phalarope

Avocet

Western Willet

Caspian Tern

Great Gray Owl

Hawk Owl

Boreal Chickadee

Chestnut-Collared Longspur

Lark Sparrow

Sharp-tailed Sparrow

Le Conte's Sparrow

Grasshopper Sparrow

Henslow's Sparrow

Yellow-breasted Chat

Prothonotary Warbler

Table 20. Rare and Endangered Animals of the Upper Mississippi River Basin (FWS, 1970)

Animal	Present Distribution
Indiana Bat Myotis sodalis Status endangered with estimated population 500,000.	Midwest and eastern United States from the western edge of Ozark Region in Oklahoma to central Vermont to southern Wisconsin, and as far south as northern Florida.
Timber Wolf Canis lupus lycaon Status endangered with estimated population 300-500.	Lake Superior Region of Michigan, Wisconsin, and Minnesota.
Southern Bald Eagle Haliaeetus leucocephalus Status endangered with about 230 active nests in 1963.	Nests primarily in Atlantic and Gulf coasts but ranges northward in summer to northern United States and Canada.
American Peregrine Falcon Falco peregrinus anatum Status rare with estimated population 5,000-10,000.	Breeds from northern Alaska to southern Greenland south to Baja California; winters in northern United States.
N. Greater Prairie Chicken Tympanuchus cupido pinnatus Status rare within Basin.	Resident locally in prairie habitat from central southern Canada south to northeastern Colorado, northwestern Kansas and northeastern Oklahoma east to northern Michigan, Indiana, Wisconsin, Illinois and Missouri.
Greater Sandhill Crane Grus canadensis tabida Status rare with an estimated population of 2,000 east of Rocky Mountains.	Breeds locally from southern British Columbia, east to southern Manitoba including Minnesota, Wisconsin and Michigan.
Lake Sturgeon Acipenser fulvescens Status rare with estimated size of population unknown.	Distributed throughout Great Lakes drainage with records from Mississippi and St. Croix Rivers.

SOCIOECONOMIC SETTING

The socioeconomic aspects of the environmental setting will be discussed (1) by identifying the three-way subdivision of socioeconomic activities used in this report, and (2) by presenting an overview of these activities in the St. Croix River area of the Upper Mississippi River.

Three Subdivisions of Socioeconomic Activities

It is useful to divide a discussion of the socioeconomic setting of the study area of the Upper Mississippi River into (1) industrial activity, (2) recreational activity, and (3) cultural considerations.

Industrial Activity

Industrial activity includes agricultural, manufacturing, transportation, and related pursuits that affect employment and income in the study area directly; this includes employment on farms, in barge operations, commercial dock facilities, lock and dam operations, and commercial fishing. While it is probably most desirable to measure industrial activity in terms of jobs or dollars generated, lack of available data makes this impossible in the present study. As a result, indices of this industrial activity--such as tons of commodities moved, industrial facilities constructed, or pounds of fish caught--are generally used.

Recreational Activity

Recreational activity has two effects of interest. One is the psychological value to the users themselves of being near or on the St. Croix and Mississippi Rivers for leisure activities. A second effect is the impact of the recreational activity on employment and income. Recreational activity is more indirect in its effect on employment and income than is industrial activity and relates mainly to leisure-time activities of people using the St. Croix and Mississippi Rivers for recreational purposes; examples include boating, sport fishing, hunting, sightseeing, camping, and picnicking. Recreational activities frequently use units of measurement like number of boaters or fishermen using a lake or river, fishing licenses sold, or visitor-days. It is often very difficult to find such measures for a particular pool on the Mississippi River. Where such data are available--such as pleasure boat lockages--they are used. Where they are not available--such as fishermen using a specific pool--proxy measurements are used; for example, number of sport fishermen observed annually by lock and dam attendants are taken as a measure of fishing activity in the pools--even though this is not as precise a measure as desired. Problems involved with placing dollar values on these recreational activities are discussed in Section 6.

Cultural Considerations

Cultural considerations are the third component of the socioeconomic setting. These considerations include three kinds of sites of value to society: archaeological sites, historic sites, and contemporary sites. These sites can include such diverse physical assets as burial mounds, historical battlegrounds or buildings, or existing settlements of ethnic groups such as Amish communities. Because of the difficulty of placing any kind of value on such sites, they are simply inventoried in the present study.

Overview of Socioeconomic Activities in the Study Area

The industrial, recreational, and cultural aspects of the St. Croix River are discussed below in relation to the entire Northern Section of the Upper Mississippi River to provide a background with which to analyze the impact of operating and maintaining the nine-foot channel in Section 3 of this report.

Industrial Activity

The existence of the Mississippi River and its tributaries has had a profound effect on the industrial development of the American Middle West. It has served as a route of easy access for transportation and communication tying together the industrialized East with the agricultural Middle West as well as the varied economies of the North and South.

Historical Development of the Waterway. The development of the Northern Section of the Upper Mississippi as a waterway for shipment has paralleled the rise of the American economy, keeping pace with the need to move bulk raw materials and heavy, high-volume commodities over the wide geographical areas served by the river network. This has allowed barge transportation to remain competitive with other forms of transportation. It is noteworthy that competing systems of land transportation such as railroads and highway trucking use the relatively gentle river valley terrain in order to simplify both engineering design and fuel energy demands. Thus, the Mississippi River Valley is intensively used to meet the transportation needs of the Midwest.

Long before the coming of the first white settlers, the St. Croix-Mississippi River System was a transportation corridor for the Indians. It was used to facilitate the primitive barter economy and as a route for other forms of social and cultural communication and contact.

In its primitive condition, the Upper Mississippi was characterized by numerous rapids and rock obstructions. Fluctuations in water flow during various seasons of the year were minor inconveniences to the Indian canoe, but demanded modification before substantial commercial use of the river could take place. Prior to improvement, [illegible] periods of high water when log rafts and small boats could pass between the Falls of St. Anthony and the mouth of the Ohio River.

The necessity of modifying the natural course of the river to make it suitable for commercial navigation gradually became apparent as the size of the river boats and barges grew. Since the first river steamboat arrived at Fort Snelling in 1823 and steamboat transportation for freight and passenger use grew to a peak in the decade 1850 to 1860 when over 1000 steamboats were active on the entire length of the river. By 1880 the growth of the railroad system in the U.S. and the lack of a channel of sufficient depth marked a decline in the use of the river for transportation. However, on the upper reaches of the Mississippi, growth in freight traffic continued. A peak was reached in 1903 with 4.5 million tons moved between St. Paul and the mouth of the Missouri River. A subsequent rapid decline coincided with a drop in river use for moving logs and lumber. In 1916 only 0.5 million tons were shipped on this section of the river. As the population and industry of the Upper Midwest region grew, there was a corresponding growth in the need for cheap coal for power generation. A technological consequence of this need was the development of the barge and towboat which gradually replaced the steamboat on the river. The barge and towboat required a deeper channel than the earlier steamboats. The need for coal in the Upper Midwest was complemented by the need to ship large quantities of grain south to other centers of population. Thus, economies were realized by having at least partially compensating cargoes going both directions on the upper reaches of the river. In the later 1920's, large grain shipments from Minneapolis began.

Although 4 1/2-foot and six-foot channels had been authorized in recognition of the increasing role of the river in the transportation network of the U.S. and technological developments in [illegible] led to the [illegible] of a nine-foot channel to [illegible] St. Croix [illegible]. By 1940 the channel and the requisite locks [illegible] completed.

When figures for tonnages shipped at various times on the Mississippi River are examined, it is difficult to make comparisons that relate to Corps' activities. For example, the following factors complicate the problem of data analysis during the period prior to 1940:

1. Statistical data collected by the Corps of Engineers covered different segment of the Upper Mississippi River during these years. Some of the reasons for this appear to be changes in the administration of river segments during that time, as well as some experimentation with better methods of statistical collection.
2. Shipping in the Upper Mississippi was distorted during the decade of the 1930's because of the construction of locks and dams in the St. Paul District.
3. From 1941 to 1945 all forms of transportation were used for the war effort without regard to maximizing economic return. Therefore, data for these years (as with the 1930's) does not necessarily reflect a normal period of transportation on the Upper Mississippi.

Barge Shipments. Table 21 shows tonnage information available for selected years from 1920 through 1945 for the river segment identified in the third column of the table.

In more recent years, data are available for the St. Paul District. Table 22 shows the movement of tonnages through the St. Paul District for the years from 1962 through 1971.

When this table is compared with the previous one, the growth of shipping on the Upper Mississippi becomes readily apparent. Thus, the total traffic for the St. Paul District in 1962 was about [illegible] traffic in 1945, which was a war year. In fact, traffic in the St. Paul District for 1962 was more than five times greater than all of the traffic on the Upper Mississippi [illegible] of the Ohio River in 1930. Traffic about doubled in the St. Paul District between 1962 and 1971. This was caused, to a large degree, by grain shipments from the District and to an increase in receipts of coal.

Table 21. River Shipment from 1920 Through 1945
(OCE, 1920 to 1945)

Year	Total Tonnage (short tons) Shipments and Receipts*	River Segment
1920	630,951	Mpls. to Mouth of Missouri River
1925	908,005	Mpls. to Mouth of Missouri River
1926	691,637	Mpls. to Mouth of Missouri River
1927	715,110	Mpls. to Mouth of Missouri River
1928	21,632	Mpls. to Mouth of Wisconsin River
1929	1,390,262	Mpls. to Mouth of Ohio River
1930	1,395,85[illegible]	Mpls. to Mouth of Ohio River
1935	188,613	St. Paul District
1940	1,097,971	St. Paul District
1945	1,263,9[illegible]	St. Paul District

*Tonnages exclude ferry freight (cars and other) and certain cargoes-transit.

Table 22. River Shipment from 1962 Through 1972
(S.P.D.-SCS)

Year	Total Traffic St. Paul District*
1962	8,10[illegible]
1963	9,26[illegible]
1964	9,6[illegible]
1965	9,[illegible]
1966	11,3[illegible]
1967	11,[illegible]
1968	10,7[illegible]
1969	[illegible]
1970	15,4[illegible]
1971	15,42[illegible]
1972**	16,361,174

* Comparative Statement of Barge Traffic on Mississippi River and Tributaries in St. Paul District, U. S. Army Engineer District, St. Paul, Minnesota

** Estimated

In 1926 data were collected on receipts and shipments for the river segment from Minneapolis to the mouth of the Wisconsin River. This approximates the navigable segment of the Upper Mississippi within the St. Paul District, and the data for this segment can be equated with data for the St. Paul District with little difficulty. In that year, 21,000 tons were received and shipped. By 1940, tonnages handled reached 1,000,000 tons annually, when the lock and dam system and the nine-foot channel were virtually complete. Tonnages reached 2,000,000 by 1946, and 3,000,000 by 1953. By 1962 over 8,000,000 tons were shipped and received in the St. Paul District. In the decade between 1962 and 1972 this had doubled to 16,000,000 tons.

Table 23 shows the number of trips made on the St. Croix in 1971.

Table 23. River Trips in 1971

Transportation Mode	Upbound	Downbound
Self propelled		
Passenger and dry cargo	1,612	1,810
Tanker	0	0
Towboat or tugboat	133	132
Non-Self propelled (barge)		
Dry cargo	790	787
Tanker	0	0
TOTAL		

Source: Waterborne Commerce of the United States Calendar Year [illegible], Part [illegible]; Department of the Army, U.S. Corps of Engineers, p. 165.

The St. Croix River has [illegible] coal dock, [illegible] devoted to the receipt of coal, and [illegible]. The St. Croix, [illegible] and the St. Anthony Falls Pools, is an end-point for shipping. This pool is not a thoroughfare for shipping passing to and from pools above it. Therefore, from an economic point of view its function is limited to handling cargo destined for the industry along the river itself.

The shipping season for most of the St. Croix River usually is eight months, from mid-April to mid-December. The navigable rivers maintained and operated by the St. Paul District should be viewed within the context of the system as a whole including the Mississippi, Ohio, Missouri and other tributary rivers. In 1964 a detailed analysis of origin-destination waterborne commerce traffic patterns showed that the average miles per ton on the Upper Mississippi River Waterway System ranged from 700 to 800 miles. This indicates that the great bulk of shipments and receipts have origins or destinations outside the St. Paul District. Each pool then in addition to its own shipments and receipts contributes to the economic benefits enjoyed by the system as a whole. Thus, any measure of the economic benefits of the river commerce on an individual pool must include the benefits that it contributes as a necessary part of the Upper Mississippi system.

Commercial Fishing. As population along the Northern Section of the Mississippi River increased, industrial specialization also took place. The result was the development and growth of commercial fishing along the Upper Mississippi in the last half of the nineteenth century and during the twentieth century.

Limited data are available on the extent of commercial fishing prior to 1930. However, the rise in the water level behind the newly-constructed locks and dams in the Upper Mississippi River after 1930 increased the fish habitat over that existing prior to the construction.

Data on commercial fishing in the 1960's in the pools in the study area are shown in Figure [illegible]. No commercial fishing occurs in St. Anthony Falls Pool and Pool 1; and almost none occurs in Pool 2. A small amount of commercial fishing is reported for Pool 3, which includes the St. Croix River. No comparable data are available specifically for commercial fishing [illegible] the Minnesota and St. Croix Rivers. In 1969, the Northern Section of the Upper Mississippi River produced about 5.5 million pounds of fish that were sold commercially;

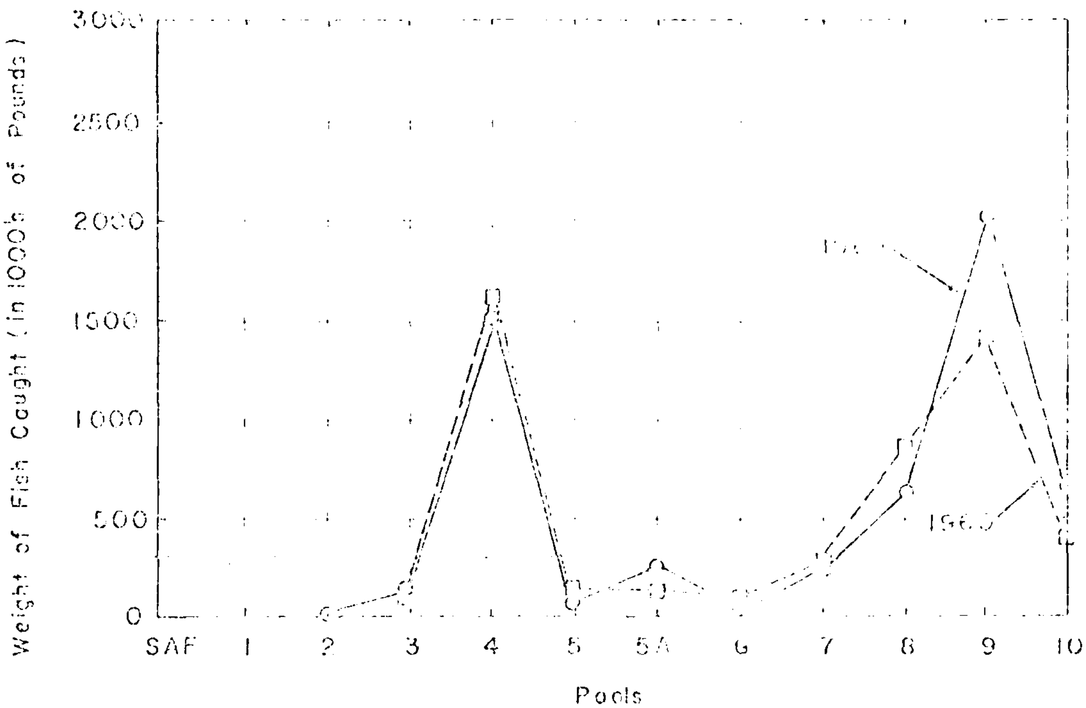


Figure 23. Thousands of Pounds of Fish Caught Annually by Commercial Fishermen in Upper Mississippi River Pools in 1960 and 1969 (UMRCC, selected years)

this was an increase of about nine percent from the 1960 total. The commercial value of the fish caught in 1969 was about $400,000.

Recreational Activity

In addition to the industrial activity described above, the Northern Section of the [illegible] recreational opportunities for the entire region [illegible] prior to Congressional authorization of the [illegible] comprehensive project on the [illegible] to St. Paul, settlers used the river extensively. The Upper Mississippi provided settlers the opportunity to boat, fish, hunt, and sightsee. However, the need for these settlers to carve out an existence in the Minnesota wilderness of the early nineteenth century meant that recreational uses of the upper river were few. Thus, boating was not for recreational purposes; it was essential for the settlers' continuing existence to move people and supplies to where they were needed. Similarly, hunting and fishing were not for sport; they provided the food needed to feed the settlers' families; surplus fish or game were sold or traded for other necessities required for daily living.

As the twentieth century dawned, leisure time accompanying the settler's higher standard of living, led to recreational uses of the Upper Mississippi River. Segregating present-day recreational uses of the study area due to Corps' operations from those existing in 1930, prior to the 9-foot channel, presents problems. These arise because of the difficulty of isolating the increased recreational uses of the river caused by more people in the region, higher standards of living, and increased leisure from those caused by improved navigational and other recreational opportunities.

A significant portion of the recreational activity on the Upper Mississippi is due (1) to the improved navigation opportunities for large pleasure craft on the river, and (2) to improved fish and game habitat resulting from higher water levels in the river. The potential for improved fishing and hunting is not always realized because increased industrialization along the river has polluted the river and has reduced the available hunting areas, which often more than offset the increased habitat.

Boating Activity and Related Facilities. As noted above, much of the increased boating in the study area of the river—and virtually all of it for the deeper draft pleasure boats—[illegible] opportunities provided by the system of locks and dams. Figure [illegible] illustrates the dramatic growth in [illegible] boating in the study area from [illegible] to [illegible]. The figure shows that number of pleasure boats moving through each lock in the study area increased by an average of about 1500 boats during the twelve-month period. In 1972, Lock 7 had the most pleasure boats move through it (over 9000), followed by Lock 3 (with over 8000).

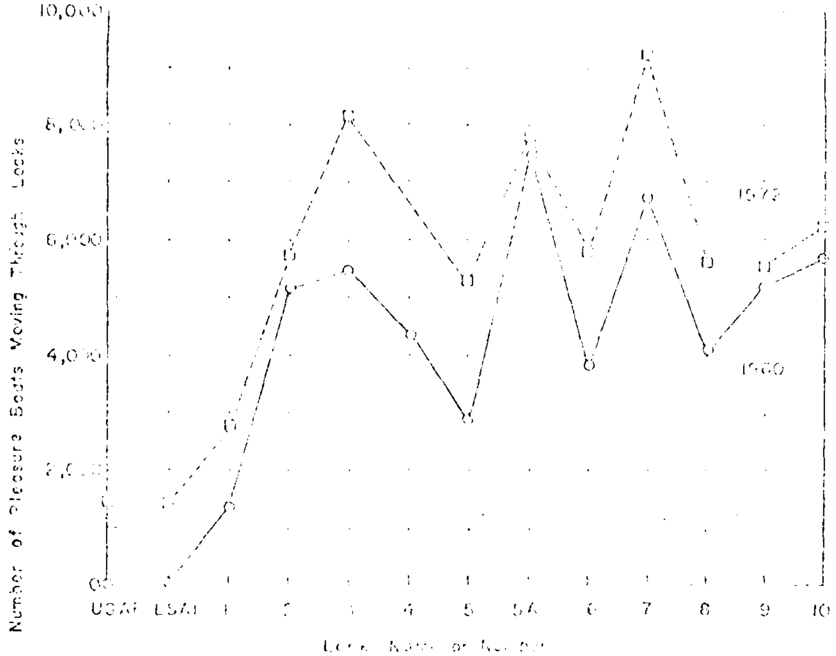


Figure 24. Pleasure Boats [illegible] Through Upper Mississippi River Locks in 1960 and 1972 (S.P.D.-ECS, selected years)

A variety of facilities have developed on the river mainly to serve the pleasure boaters. These include numerous small boat harbors, marinas, and boat clubs--as well as recreational sites and restaurants. Approximately 24 public and private recreational sites have been identified along the river through maps, charts, literature and personal observation. These are both public and private sites, many with [illegible] access to the river and many with additional facilities for hiking, picnicking and sightseeing. The St. Croix River is rich in aesthetic [illegible] which [illegible] visitors. [illegible] visitors [illegible] a Scenic River by Congress.

Within the [illegible] two years a p[illegible] [illegible] boat, the "[illegible]", operates out of Stillwater.

A study of recreational activity on Lake St. Croix was conducted by the MDNR from 1968 through 1971 (Kr[illegible], 1972). The use intensity ([illegible] hours, campnights) of various recreational activities [illegible] for 1969-[illegible] (Krauch, 1970). The most popular form of recreation was fishing, followed by pleasure boating (see Table 24).

Table 24. Popularity of Various Forms of Recreation on Lake St. Croix in Terms of Intensity of Use ([illegible]) (Krauch, 1970)

Recreational Activity	Intensity	
Pleasure boating (boat-hours)	91,180	
Water skiing (man hours)	7,416	
Camping (camp nights)	1,005	
Fishing (man hours)	106,280	
Bank		25,611
Boat		76,094
Ice-fishing		4,575

Sport Fishing [illegible] Lake St. Croix [illegible] a popular [illegible] area. Of the 1550 fishermen interviewed by the [illegible] during 1968-69, about 44 percent were fishing for [illegible] percent [illegible] of fish, and 7 percent were fishing for catfish.

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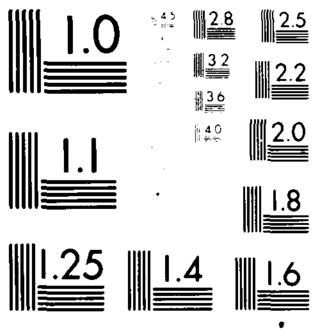

MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS-1963-A

Fishing from boats was the most common, followed by bank fishing (see Table 24). One popular site is the discharge canal of the NSP power plant.

The MNDNR 1968-69 survey showed that about 100 anglers were from out-of-state: from California to Virginia, and from Texas to Canada (Table 25).

No hunting data is available.

Sightseeing and Picnicking. Studies in general indicate that a body of water is often essential for most recreation activities. People want this water not only to boat on or to fish or swim in, but also simply to look at, picnic beside, and walk along. The study area of the Upper Mississippi has served this purpose for settlers for two centuries. Again, because precise data are lacking, it is generally difficult to isolate the effect of the Corps' operations on recreational activities such as sightseeing, picnicking, and hiking. A variety of parks exist along the river that are available for sight-seeing and other recreational activities. Spoil sites, such as on the Kinnickinnic River delta (Mile 6.0), also are popular for sight-seeing and other recreational activities.

Cultural Considerations

A number of archaeological, historical, and contemporary sites exist in the study area of which three occur on Lake St. Croix. Although the bulk have been unaffected by Corps' operations, these sites in several pools have been hurt by the rising water level caused by dam construction. These sites on Lake St. Croix are not known to have been affected by Corps' activities. However, they are potentially destroyable (see Appendix E).

Table 25. Number of Interviewed Anglers from States Other Than Minnesota or Wisconsin (Kresch, 1970)

State	No. of Anglers	State	No. of Anglers
Iowa	45	Ohio	2
Illinois	32	Washington	2
Colorado	6	North Dakota	1
Indiana	3	Virginia	1
California	3	Missouri	1
Oklahoma	2	West Virginia	1
Texas	2		
Nebraska	2	Canada	1

TOTAL 102

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3. THE ENVIRONMENTAL IMPACT OF THE PROJECT

INTRODUCTION

Impacts are understood here to be environmental responses to human activities. This study deals only with those impacts likely to be the result of the Corps of Engineers' nine-foot channel project in the lower 25 miles of the St. Croix River, know as Lake St. Croix.

Because little detailed information appears to exists which describes such impacts in Lake St. Croix, the impacts listed below were derived from:

1. field data collected from Lake St. Croix and the Mississippi and Minnesota Rivers during 1973;
2. information from previous studies in Lake St. Croix made for other purposes;
3. information from studies elsewhere on the Mississippi River;
4. basic ecological and socioeconomic principles and processes;
5. personal experience of the investigators.

Field studies during the summer of 1973 extended the data base to provide further information on at least the major impacts.

The Corps project which produced these impacts includes (a) the maintenance dredging of a nine-foot channel in Lake St. Crois; (b) the presence of Lock and Dam 3 at Mississippi River Mile 796.9, and (c) the operation of these structures; additional impacts arise from (d) navigation by commercial and private vessels on the river and from their attendant facilities, all of which is provided for by the channel. The environmental impacts of this project are the changes brought about in the physical and biological components of natural systems, and in changes in the cultural, economic, recreational, archeological, and aesthetic components of socioeconomic systems.

NATURAL SYSTEMS

Identification of Impacts

The initial impacts of impoundment and dredging by the Corps of Engineers upon the natural systems in Lake St. Croix are:

1. turbidity and a bare area created by dredging and spoiling;
2. burial of aquatic and terrestrial habitat due to spoiling, and formation of bare, erodable soil;
3. changed swamp into a shallow lake and decreased floodplain area due to impoundment;
4. increased incentive for developing the floodplain and riverbanks, due to navigation channel.

The initial impacts listed above originate from Corps' operations and maintenance activities, navigation, barge terminals, and related facilities and to preproject activities (such as snagging and cleaning activities). These are presented in Tables 26 , 27 , and 28 . From initial impacts, stem the "secondary" and "subsequent" environmental impacts which are then traced further, if possible, in the discussion section.

It should be noted that the impacts in Lake St. Croix are not always completely isolated and ascribable to the Corps because they are part of a complex, multi-dimentional web of physical-chemical, biological, and socioeconomic action and reaction. Impacts also arise at least partially from other economic and cultural activities and from natural environmental processes in the local area as well as in the larger basin.

Discussion of Impacts

Environmental impacts of the nine-foot channel project in Lake St. Croix apparently have not been studied previously. However, there appears to be several impacts which may be identified and probably are due mainly to (a) increased water depth, (b) dredging, and (c) commercial navigation and attendant facilities. These impacts are part of, and may interact with, other impacts coming from human activities along the river valley.

Table 26. Probable Impacts of Operating and Maintaining the Nine-Foot Channel Project Upon the Components of Natural Systems of Lake St. Croix.

Project Feature	Initial Impacts	Secondary Impacts	Subsequent Impacts
Maintenance dredging	1. Increase turbidity	1. Cover benthos, plants 2. Suffocate fish, spawn 3. Reduce water quality	1. Reduce biota
	2. Exposes new sterile substrate.	1. Loss of benthos	1. Decrease fish, waterfowl, vegetation, decrease wildlife.
Spoil deposition	1. Decrease in marsh or terrestrial vegetation	1. Spreads to cover more habitat; redeposited in channel	1. Decrease vegetation; decrease wildlife 2. Confines channel 3. Fills floodplain
	2. Increase floodplain area	1. Increase marsh and terrestrial plants and animals.	1. Decrease erosion
		2. Decrease flood capacity	1. Increase flood damages
	3. Confines channel	1. Decrease backwater circulation	1. Isolate backwaters 2. Decrease benthos, fish, wildlife
		2. Isolate backwater	1. Decrease berthos, fish, wildlife
	4. Provide recreational sites	1. Increased aesthetic enjoyment 2. Increased disturbance of fish and wildlife	

Table 26. Probable Impacts of Operating and Maintaining the Nine-Foot Channel Project Upon the Components of Natural Systems of Lake St. Croix (Continued)

Project Feature	Initial Impacts	Secondary Impacts	Subsequent Impacts
Snagging and debris clearance	1. Decrease benthos, turtles	1. Decrease fish	1. Decrease waterfowl, recreation (fishing, bird watching)
	2. Increase turbidity	1. Decrease fish, benthos	1. Decrease waterfowl, recreation (fishing, bird watching) 2. Reduce aesthetic appeal of area
	3. Reduce aesthetic appeal of disposal area	1. Reduce recreation	
Dam #3	1. Impoundment of river (raised water levels)	1. Flooded backwaters	1. Decreased marsh vegetation and wildlife, such as muskrat, otter. 2. Decrease floodplain: increase flood level
		2. Flooded dry land	1. Decreased floodplain 2. Decreased terrestrial habitat: decreased terrestrial upland biota 3. Increased shallow water habitat; increased vegetation, fish, benthos, waterfowl.
		3. Increased depth, slowed current	1. Decreased flowing-river species of fish, clams 2. Moved point of maximum sediment deposition upstream

Table 26. Probable Impacts of Operating and Maintaining the Nine-Foot Channel Project Upon the Components of Natural Systems of Lake St. Croix (Continued)

Project Feature	Initial Impacts	Secondary Impacts	Subsequent Impacts
Dam #3 (continued)			3. Submerged riffles, decreasing benthos, fish 4. Increased conversion of remaining floodplain and bluff top to industry; increasing flood damage; decreasing water quality. 5. Increased rate of sewage degradation; decreased local water quality downstream 6. Reduced water level fluctuation; improved for motorized craft; reduced flowing-river canoeing.

Table 27. Probable Impacts of Commercial Navigation and Barge Terminals and Maintenance Facilities in Natural Systems of Lake St. Croix.

Activity or Structure	Initial Impacts	Secondary Impacts	Subsequent Impacts
Navigation	1. Increased turbidity	1. Decreased aquatic biota	1. Decrease in wildlife and waterfowl
	2. Increased bank (shore) erosion	1. Increased turbidity	1. See second and subsequent impacts above
	3. Increased fumes and effluents adverse to existing biota	1. Decreased aquatic biota 2. Decreased aesthetics	
	4. Possibility of oil spills and hazardous materials		
	5. Increased aesthetic interest		
Barge terminal, fleeting area, dry dock	1. Adverse effluents	1. Decreased aquatic biota	1. Decreased waterfowl, furbearers
	2. Loss of terrestrial habitat	1. Decreased wildlife	
	3. Increased noise level	1. Decreased wildlife	
	4. Adverse aesthetics		
Barge cleaning facility	1. Adverse effluents	1. Decreased aquatic biota	1. Decreased waterfowl, furbearers
	2. Decreased aesthetics		

Table 28. Probable Impacts of Corps Activity and Structures Prior to 1930 upon Natural Settings of Lake St. Croix.

Project Feature	Initial Impacts	Secondary Impacts	Subsequent Impacts
Removal of snags, wrecks, shoals, and sandbars, beginning about 1878	1. Increased turbidity	1. Decreased benthic organisms, fish	1. Decreased waterfowl, furbearers
	2. Decreased benthic substrate		
Construction of a dyke, beginning about 187[illegible]	1. Increased quarrying, cutting of brush	1. Loss of terrestrial habitat	1. Decreased wildlife 2. Increased runoff, erosion, sedimentation
	2. Increased turbidity	1. Decreases in aquatic biota (fish, benthos)	1. Decreased waterfowl, furbearers
	3. Increased habitat for benthic organisms	1. Increased aquatic biota (fish, benthos)	1. Increased waterfowl, furbearers
	4. Channelized river	1. Reduced water surface, habitat as sediment collected behind wing dams	1. Decreased aquatic biota; decreased waterfowl and furbearers
	5. Reduced bank erosion	1. Decreased formation of new backwaters	1. Decrease of backwater biota
		2. Reduced turbidity	1. Increased aquatic biota (fish, benthos)
Extension of 6-foot channel to Stillwater, beginning in 1927	1. Dredging	1. Increased turbidity	1. Decreased benthos, fish
		2. Increased bare area	1. Increased benthos, fish 2. Decreased wildlife

Human impacts on river valley ecosystems developed as the river grew in importance as a trade route. In the nineteenth century, river transportation, which was important earlier in the fur trade, intensified as the land was plowed, the forests lumbered, and cities flourished. These alterations in the watershed probably yielded greater runoff carrying more sediment and nutrients to the river. Water levels may have changed more drastically, possibly leaving larger areas of exposed beach or river bottom. These changes probably led to greater bank erosion, increased size and number of sandbars and snags, and cutting off and filling in of the small backwater areas.

The increasing importance of the Mississippi and thus the St. Croix River, transportation to the economy of the Midwest led Congress to direct the Corps of Engineers to develop the river for commercial navigation. Initially, impacts were limited to loss of substrate through the removal of snags and boulders. Later, channelization by wing and closing dams, dikes, and by dredging brought larger-scale impacts.

Effects of Maintenance Dredging

Nearly 41,000 cubic yards annually are dredged from the St. Croix River, or about 1,700 cubic yards/mile/year (See Table 29). However, most of the dredging occurs at the mouth of the Kinnickinnic River, and some at Hudson and Catfish Bar (Mile 11.7) [illegible] IV). Both the average annual volume and the average [illegible] with the other pools in the St. Paul District. [illegible] the potential public recreation area. Indeed some [illegible] the Kinnickinnic River delta (Mile 6.0) appear quite [illegible] boats and picnics. However, the [illegible] upon the large number of visitors because the [illegible] comprise most of the present [illegible] Lake St. Croix and stand in striking contrast to the steep, wooded bluff slopes.

Table 29. Quantity of Sediment Dredged per Year from the Mississippi River and Navigable Tributaries in the St. Paul Engineer District (Calculated from data from S.P.D.--NCS, 1973)

Pool or Tributary	Average Annual Volume Per Year (in cubic yards)	Average Annual Volume Per Year Per River Mile (in cubic yards)
St. Anthony Falls	23,522	5,470
Pool 1	125,640	22,042
Minnesota River	12,253	834
Pool 2	175,126	5,422
St. Croix River	40,836	1,667
Pool 3	112,187	6,130
Pool 4	487,836	11,062
Pool 5	235,969	16,052
Pool 5A	152,302	15,865
Pool 6	95,371	6,716
Pool 7	150,303	12,738
Pool 8	282,549	12,127
Pool 9	155,000	4,984
Pool 10	94,313	2,875
Total 14 — Total Annual Volume, St. Paul District	2,143,207	

Average Annual Volume per Pool 153,086

Average Annual Volume per Mile 8,856

The effects of dredging may spread beyond the site and last longer than just the dredging period. Dredging creates a sterile area of the river bottom and increases turbidity in the river. Turbidity may be harmful to fish and other aquatic animals, as well as possibly reducing the productivity of algae and aquatic plants.

The resuspended sediments causing the increased turbidity become redeposited downstream, possibly smothering bottom organisms and removing fish habitat. A study of the effects of dredging upon turbidity revealed that a threefold increase in turbidity at the water surface and bottom occurred 100 feet downstream from the clamshell dredge. While turbidity returned to "normal", the turbidity on the bottom was still nearly double the "normal" level almost a mile downstream (Figure 25). The coarser sand of the St. Croix River may not yield as much turbidity, or for such a great distance as was found on the Minnesota River.

The unstable, unconfined spoil banks usually begin eroding as soon as they are deposited, with the resuspended sediments causing increased turbidity and redeposition downstream. This sediment probably smothers bottom organisms and removing fish habitat (and often requiring redredging downstream in the navigation channel).

While turbidity may persist only as long as dredging proceeds, the recolonization of the bare river bottom may take years. Mollusks have been reported to take ten or more years to recolonize a dredged area (Stansbery, 1970).

Thus it seems that the effects of dredging [illegible] natural environment not only on the site but farther downstream, and through a longer period of time than at the actual site and time of dredging.

At Hudson, dredging may be endangering what may be the last remnant population of the once common Lampsilis Higginsi (Krosch, personal communication).

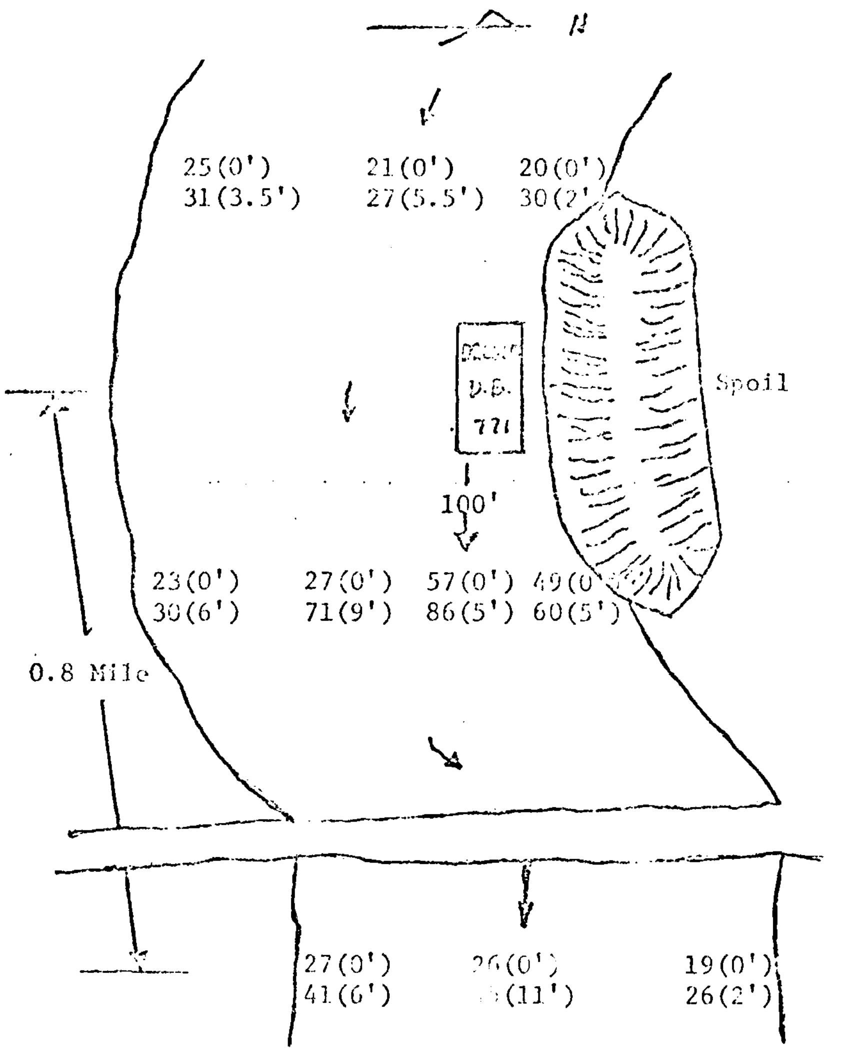

Figure 25. Effect of Clamshell Dredging Upon Turbidity in the Minnesota River, September 25, 1973
Depth in feet in ( )

Impoundment Effects

Water depth increased 5-1/2 to 6 feet due to formation of Pool 3 behind the Red Wing Dam (Dam 3). The increased depth of Lake St. Croix resulted in a 29 percent increase in "mainchannel" water surface area (See Table 30). However, impoundment decreased the area of islands by 62 percent and that of deltas by 87 percent. The initial decrease in island area has since been somewhat offset by the formation of new islands from the deposition of spoil at Hudson, Wisconsin.

Table 30. Changes in Acres of Lake St. Croix Surface Features

Surface Feature	Acres 1930	Acres 1970	Percent Change
"Main Channel"	6954.1	8964.3	29 percent
Backwater	no data	769.8	
Islands, total	148.9	56.1	-62 percent
(at Hudson)		(27.9)	
(at Stillwater)	(148.9)	(28.2)	
Deltas, total	305.8	40.0	-87 percent
(at Kinnickinnic River)	(81.0)	(40.0)	
(at Willow River)	(125.0)	0	
(at Brown's Creek, Stillwater)	(96.8)	0	
Spoil, total	0	35.6	
(at Kinnickinnic River)		(23.1)	
(at Hudson)		(12.5)	

Submergence of portions of the river deltas possibly reduced populations of shallow-water species of reptiles, amphibians, fish, waterfowl, etc. The decrease in shallow-water or marsh areas may have been relatively important in Lake St. Croix by virtue of the scarcity of those areas in the Lake.

One of these sites was a wild rice bed of about 15 acres located just upstream from Stillwater (See Figure 26). This is nearly the southern limit of wild rice in Minnesota (See Figure 27). [Several beds have been found in the backwaters of the Mississippi and Vermillion River at Prairie Island (Miller, 1973).] The quantitative determination of the impact of the decrease in shallow-waters or marsh areas on the biota of the lake have not been made.

In the Mississippi River, into which the St. Croix River flows, some species of waterfowl, wildlife, and fish have benefited at the expense of other organisms. For instance, carp and sludgeworms increased while skipjack, Ohio shad, and blue sucker have nearly been eliminated from the river.

> "Near elimination of the skipjack has also greatly reduced the commercially important and valued 'niggerhead' clam population in the river. The skipjack served as host for the larvae of these mussels. Also directly affected by pool creation have been the American eel, the blue catfish, and the paddlefish, among others. These latter fishes were once valuable commercial species, widely distributed before the river was blocked by dams. In general, the effects of pooling are to reduce to a monotype what was once a highly diversified and productive aquatic habitat. In the process, many [illegible] and populations of preferred sport fishes decline." (Ortman, 1973).

Slowing of a rapid, free-flowing river into a slackwater pool plus a heavy pollutional load has probably resulted in a reduction of the mollusk community in some parts of the Mississippi River. These reductions and losses may also have affected populations in the St. Croix River.

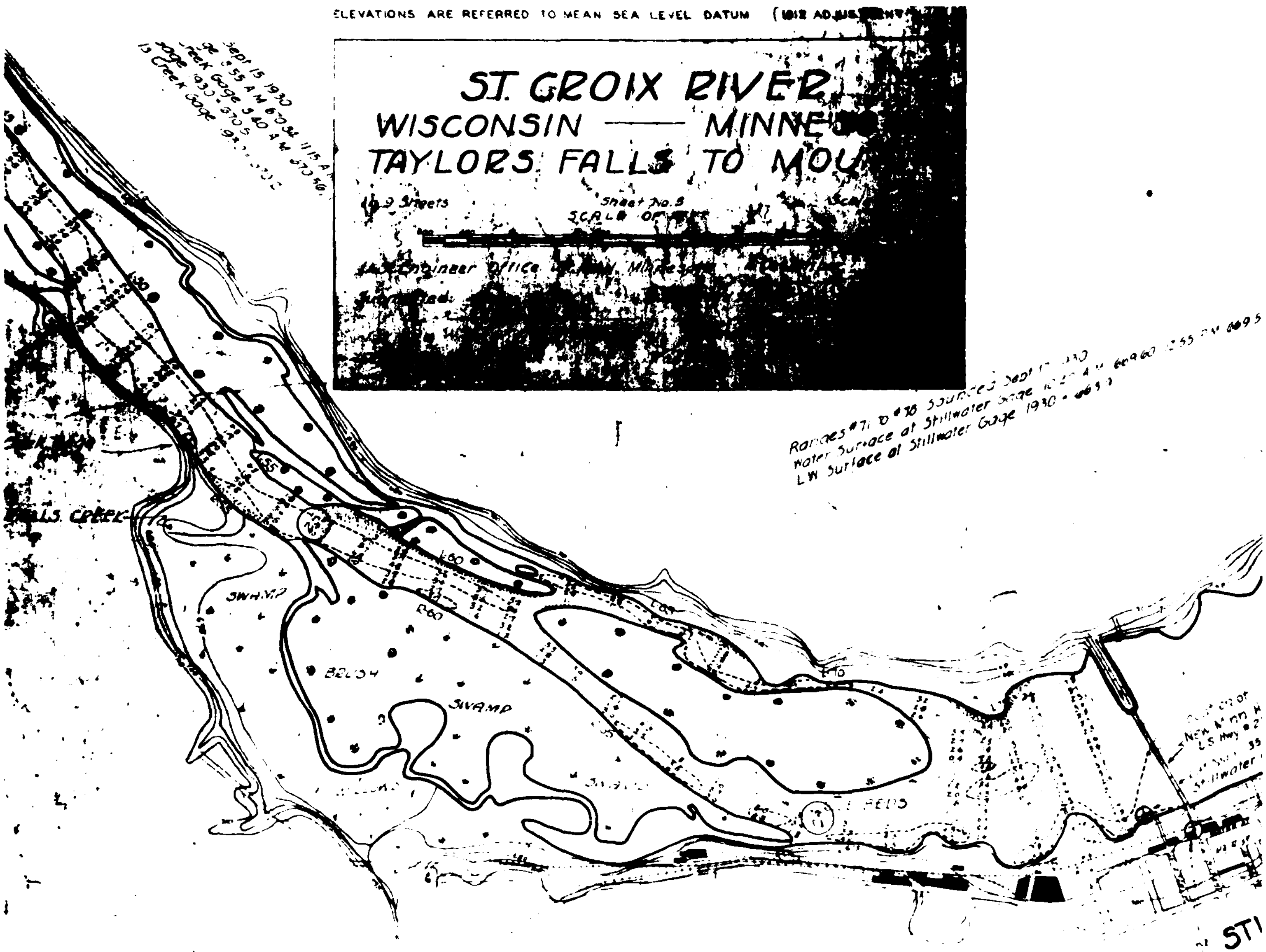

Figure 26. Map of Islands on the St. Croix River Just Upstream from Stillwater, 1930. Note the rice beds around the large island which is adjacent to the Brush Swamps (S.P.D.-NCS, 1930).

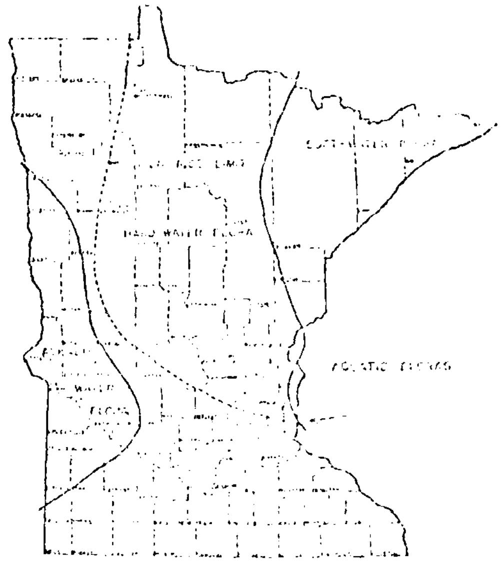

Figure 27. Range of Wild Rice in Minnesota. Arrow shows southern limit at St. Croix River (Moyle, 1956)

Apparently most mollusks require a "lively current", and a migrating fish community in order to disperse and maintain productivity. The migration of fish is prevented (or discouraged) by dams (Ortmann, 1909) and falls, although navigation locks may occasionally provide a means to bypass this barrier. Grant (1885) found 27 species of mussels in the Mississippi River at Fort Snelling in the 1880's, while more recently only 10 species were located (at Nininger) (Dawley, 1947). At Red Wing, downstream from Lock and Dam 3, 35 mollusk species were found (See Table 31). This reduction in diversity may be the result of urbanization, particularly in [illegible] to [illegible], as well as the channel project itself.

By contrast, the [illegible] 33 species of clams (See Table 14 in Section 2) of which 16 species were obtained from Lake St. Croix (Table 32). Thus the St. Croix River is of noteworthy importance since it may be a refuge for mollusks of large rivers, and may be a reservoir from which the Mississippi River in the Twin Cities area may be "reseeded" when water quality improves.

Table 31. Distribution of mussels in the Mississippi River (Dawley, 1947)

	Aitkin	Above Cass Lake	Brainerd	Fort Ripley	Little Falls	Clearwater	Elk River	Dayton	Anoka	Fridley	Minneapolis*	Red Wing*	Lake City**	Minneiska	Winona*	[illegible]*
1. *Fusconaia undata*												x	x	x	x	
2. *Fusconaia ebenus*												x	x	x	x	x
3. *Megalonaias gigantea*												x	x		x	
4. *Amblema peruviana*												x	x		x	x
5. *Amblema costata*												x				
6. *Quadrula quadrula*											x	x	x			
7. *Quadrula pustulosa*											x	x		x	x	x
8. *Quadrula metanevra*											x	x	x		x	x
9. *Tritogonia verrucosa*											x	x	x	x	x	x
10. *Cyclonaias tuberculata*												x				
11. *Plethobasus cyphyus*												x		x		x
12. *Pleurobema cordatum coccineum*													x			
13. *Elliptio dilatatus*											x	x	x	x	x	
14. *Elliptio crassidens*												x	x		x	
15. *Lasmigona complanata*	x	x														
16. *Lasmigona costata*												x	x	x	x	
17. *Lasmigona complanata*												x	x	x	x	
18. *Anodonta grandis*		x					x	x	x			x	x			
19. *Anodonta gigantea*												x	x			
20. *Anodonta corpulenta*												x	x		x	
21. *Utterbackia imbecillis*										x			x			
22. *Anodontoides ferussacianus*	x	x														
23. *Alasmidonta marginata truncata*												x			x	
24. *Arcidens confragosus*												x		x		
25. *Strophitus rugosus*												x	x			
26. *Obliquaria reflexa*												x	x	x		x
27. *Obovaria olivaria*												x			x	x
28. *Actinonaias carinata*			x	x						x	x	x		x	x	x
29. *Truncilla truncata*											x	x	x		x	
30. *Truncilla donaciformis*												x				
31. *Plagiola lineolata*											x	x	x	x		
32. *Leptodea fragilis*												x	x			
33. *Proptera alata megaptera*											x	x	x		x	x
34. *Proptera laevissima*												x	x			
35. *Carunculina parva*													x			
36. *Ligumia recta latissima*		x	x	x	x	x	x	x	x	x		x	x	x	x	x
37. [illegible]																
38. [illegible]			x							x			x			x
39. *Lampsilis ventricosa*		x	x	x	x	x	x	x	x	x	x	x	x			x
40. *Lampsilis higginsi*												x				x
No. species		2	[illegible]	4	3	3	7	4	4	5	10	[illegible]	[illegible]	15	20	14

* Below Minneapolis
** on Lake Pepin

Table 32. Distribution of Mussels in the St. Croix River (Dawley, 1947)

	Federal Rec. Area in Pine Co.	Taylors Falls	Marine	Lake St. Croix	Kettle R.	Big Sand Creek	Wood Creek	Sunrise R.	Snake R.	Grindstone R.
1. *Fusconaia* [illegible]		X	X	X						
2. *Fusconaia* [illegible]		X				X	X			
3. *Megalonaia* [illegible]				X						
4. *Amblema* [illegible]				X						
5. *Amblema* [illegible]			X							
6. *Amblema* [illegible]					X			X	X	
7. *Quadrula* [illegible]		X	X	X						
8. *Tritogonia* [illegible]		X		X						
9. *Cyclonaias* [illegible]				X				X		
10. *Plethobasus* [illegible]		X								
11. [illegible]		X							X	
12. *Elliptio* [illegible]	X		X							
13. *Lasmigona* [illegible]							X	X		X
14. [illegible]									X	
15. [illegible]				X						
16. *Anodonta* [illegible]				X			X			
17. *Anodonta* [illegible]			X							
18. [illegible]			X							
19. [illegible]							X			
20. *Alasmidonta* [illegible]								X	X	
21. *Strophitus* [illegible]	X	X		X	X	X		X		X
22. *Obliquaria reflexa*		X		X						
23. *Obovaria* [illegible]	X	X						X		
24. *Actinonaias* [illegible]	X		X		X	X		X	X	
25. *Truncilla* [illegible]				X						
26. *Leptodea* [illegible]		X		X						
27. *Proptera* [illegible]									[illegible]	
28. *Proptera* [illegible]			[illegible]							
29. *Carunculina* [illegible]										
30. *Ligumia* [illegible]	X		X	X	X				X	
31. *Lampsilis* [illegible]	X							X	X	
32. *Lampsilis* [illegible]	[illegible]		[illegible]					X	X	
33. [illegible]				X						
No. Species:	7	11	11	16	4	3	4	9	9	2

Effects of Lock and Dam Operation

Since the water level in Lake St. Croix is the same as Pool 3, the operation of Lock and Dam 3 at Red Wing will have direct impact upon the Lake.

As stated above, dams may prevent migration of fish, clams and other organisms; locks, however may provide a by-pass, although apparently no data is available. Since sauger apparently migrate from Lake St. Croix into the Mississippi River (Krosch, 1973), the blockage of fish migration at Red Wing might be a significant impact and is certainly worthy of further investigation.

Moderation of water level changes may be of some benefit to fish and wildlife in Lake St. Croix. However, although no information is available for the Lake, water level changes have been reduced to protect fish and wildlife in the Upper Mississippi River Refuge by virtue of the Anti-drawdown Law of 1924 (S.P.D.-NCS, 1969).

Effects of Navigation

Commercial navigation and barge terminals which are dependent upon the nine-foot channel, as are also pleasure boats and marinas, may have adverse environmental effects on Lake St. Croix.

Turbidity increases two- to three-fold by resuspension of bottom sediments due to propellor turbulence, and by bank erosion due to the breaking of waves within 30 seconds after a tow passes (See Figure 28). Even 30 minutes after passing the turbidity may be 1-1/2 times that prior to passage of the tow. The amount and duration may be less on the St. Croix, because of coarser sediments, than in the site on the Minnesota River.

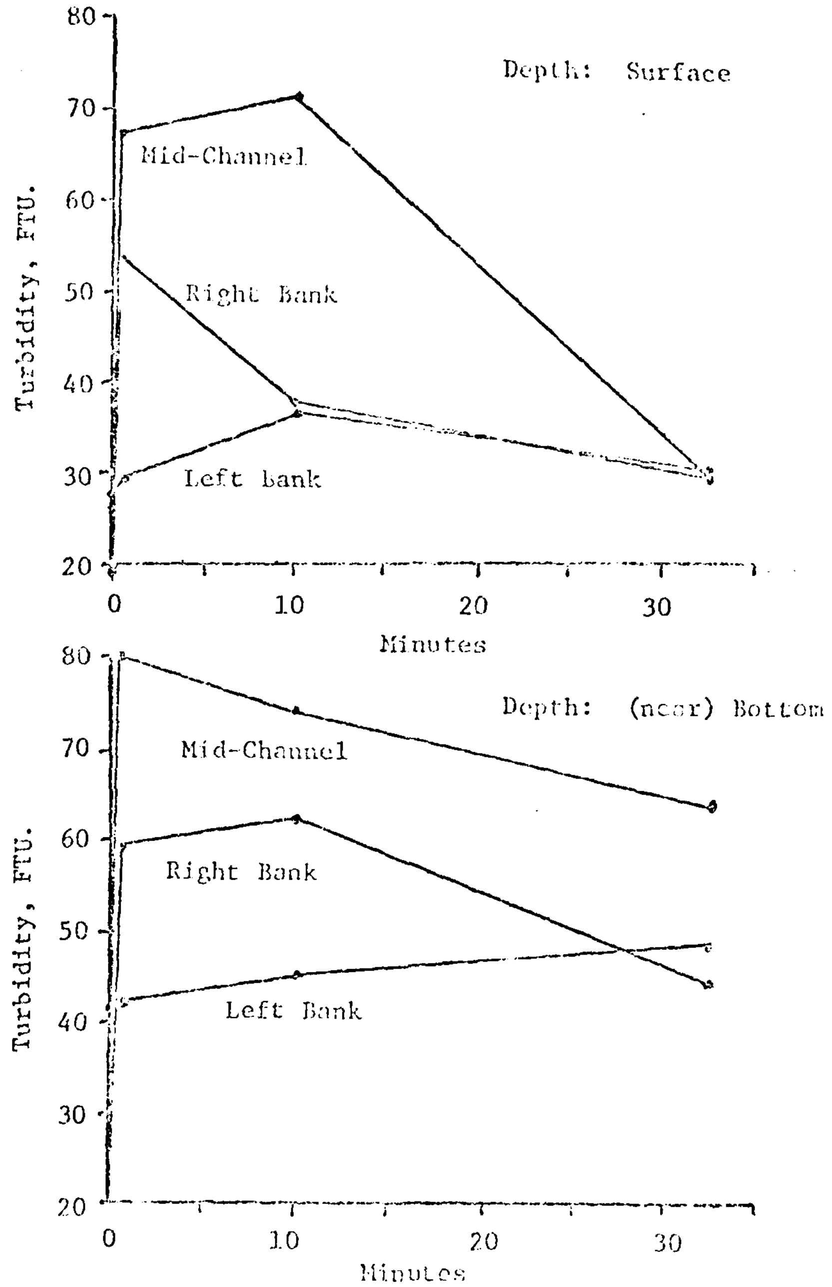

Figure 28. Duration (in minutes) of Increases in Turbidity Due to a Tow Boat on the Minnesota River at Mile 13.3, from the Right Bank to the Left Bank on September 25, 1973

Spills and discharges coming from the vessels, barge terminals, and marinas may be adverse to the environment. Commercial traffic may provide aesthetic appeal, but may also disrupt fish and water fowl behavior.

Pre-Project Activities

Pre-project impacts apparently were due to dredging and snagging operations, and to construction of a dike.

Channel maintenance, as discussed above, increases turbidity and removes natural habitat, which requires considerable time before it is reinhabited.

Construction of the dike probably caused adverse effects due to brush-cutting, quarrying and laying the dike. However, the new shallow substrate may have provided good habitat for benthic organisms and fish.

SOCIOECONOMIC SYSTEMS

Specific impacts of Corps' operations on the subdivision of socioeconomic systems for Lake St. Croix are identified below and then discussed in detail.

The socioeconomic impacts originate from the Corps' nine-foot channel; specifically the maintenance dredging and the resulting commercial traffic and related facilities. These project features plus the locks and dams and dredging on the Mississippi [illegible] navigation channel extending from Stillwater 838 miles downstream to Cairo, Illinois.

Identification of Impacts

The impacts of this river-born commerce and the Corps' project features which provide the channel may be divided into industrial, recreational, and cultural effects. At present it is possible only to estimate these impacts, by using the number of facilities and vessels, and, where possible, the number of people involved. However, information is not as yet available on which to base the dollar value of these impacts.

Industrial Impacts

The principal industrial impacts are:

1. Barge transportation on the St. Croix and Upper Mississippi that leads to:

   a. An increase in commercial docks on the River and attendant employment;

   b. Location of industrial plants along the River whose raw materials or products lend themselves to shipment by barge; this contributes direct employment in these plants and indirect employment in firms--

      (1) providing goods or services as inputs to the barge-oriented plants,

      (2) using the outputs of these plants or raw materials for their own operations,

      (3) reducing the shoreline area for recreation, and access to the river, or

      (4) reducing aesthetic appeal of the lake St. Croix valley.

   c. A decline in the quality and increased turbidity of water in some portions of the St. Croix River due to--

      (1) dredging and spoiling,

      (2) effluents produced by barges and barge-oriented plants, and

      (3) turbidity caused [illegible] boats.

2. Additional employment due to the maintenance of the channel;

3. Potential increase in commercial fishing due to increased acreage [illegible] level. This potential has not always been realized for reasons developed below.

To summarize, beneficial industrial impacts that result from operating and maintaining the nine-foot channel by the Corps of Engineers are an increase in the number of industrial plants and commercial docks along the St. Croix River with their associated employment, and an increase in the potential for fishing. The detrimental effects are a decline in water quality due to river barges and the related industrial plants along the River.

Recreational Impacts

The principal recreational impacts are:

1. An increase in recreational boating due to more stable, navigable water levels which leads directly to more marinas—and their accompanying employment,
2. A possible increase in fishing due to an increase in fish habitat resulting from rising water levels.

The effects cited above are positive except for those due to increased industrial activity (barge traffic and industrial plants) that may hurt fishing and recreational boating.

Cultural Impacts

At this stage of research no archeological, cultural, or contemporary sites of cultural significance on the St. Croix are known to have been affected by Corps' operations.

Discussion of Impacts

The industrial and recreational impacts identified above are examined in detail in the following three sections.

Industrial Activities

The economic effect of the activities of the Corps of Engineers on The St. Croix River in the St. Paul District can be measured mainly in terms of three major elements. They are:

1. The channel itself with its associated locks and dams and navigational aids;
2. The installations at riverside for the transfer of cargo, storage facilities, and access;
3. The vessels using the waterway.

In these terms the impact of the Corps' activities on the St. Croix River is not as great as in some of the other pools in the Northern Section of the Upper Mississippi River.

Barge Activity. The greatest and most obvious impact of the activities of the Corps of Engineers has been the modification of the transportation system due to the growth of barge traffic. The visual evidence of the impact is seen in the physical structures (e.g., commercial docks and terminals, etc.) on the shores and the barge tows moving along the river. However, the St. Croix River has not been the origin or terminal for most of the commodities that move in barges along the Mississippi River system. Indeed, it serves almost exclusively as a terminal for products (principally coal). The amount of barge freight originating in the St. Croix is negligible.

Figures 29 and 30 show graphically the growth of receipts into and shipments from the St. Paul District in the 30 years from 1940 to 1970. Commodities shown in the figures, with the exception of coal for the two utilities in Pool 9, flow through the pool enroute elsewhere. Although receipts still substantially exceed shipments, the growth in shipments (89 percent grain) from the district in these three decades indicates the great impact of the river on the regional economy.

In 1970 some rough projections (based on 1964 data) were made of the growth of commerce in the St. Paul District (UMRCBS, Study Appendix J, 1970). The projections suggest that the tonnage of barge traffic moved in the Upper Mississippi River basin will about double from 1964 to 1980 and about triple from 1964 to 2000.

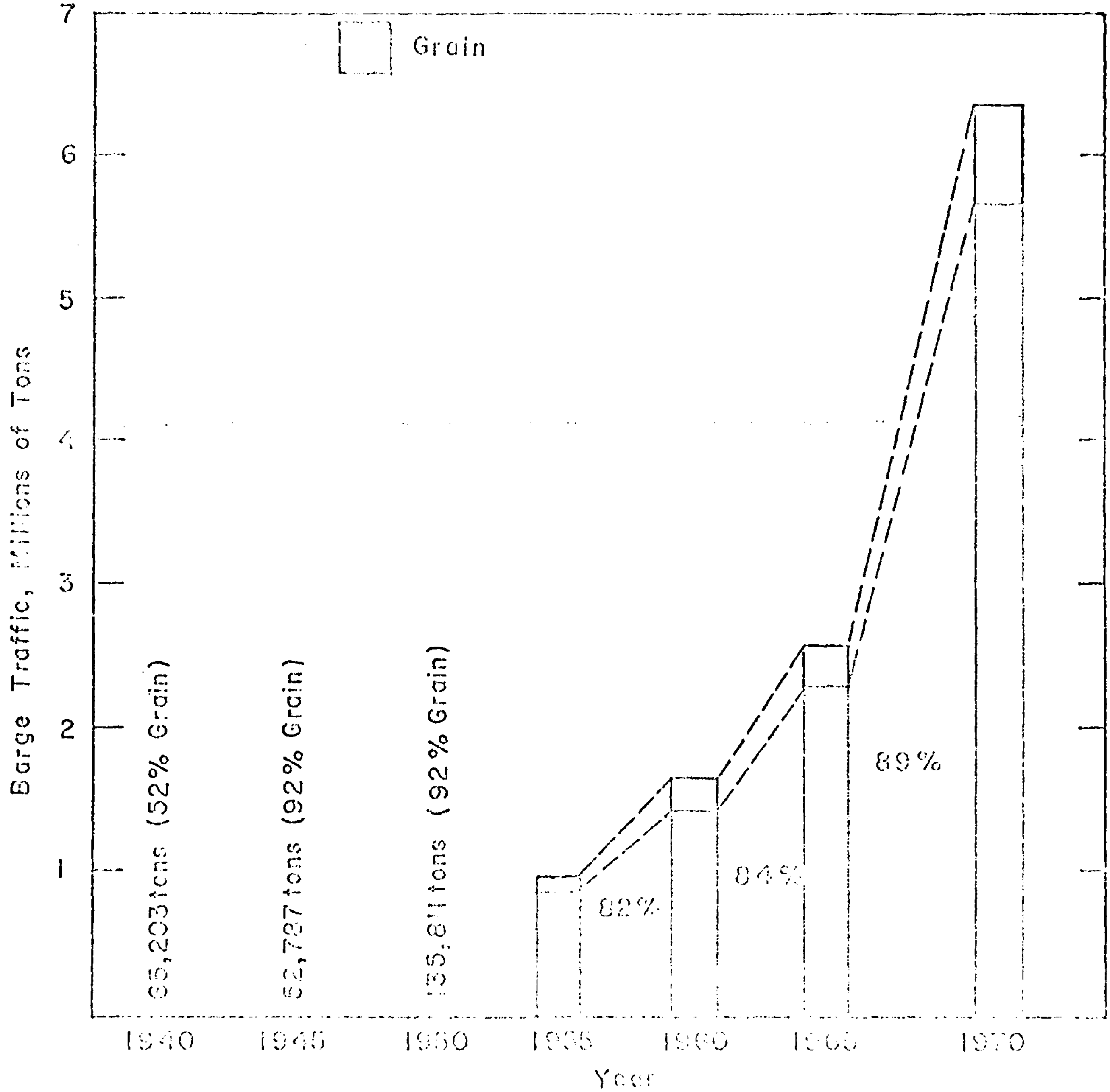

Figure 29. Shipments Out of the St. Paul District

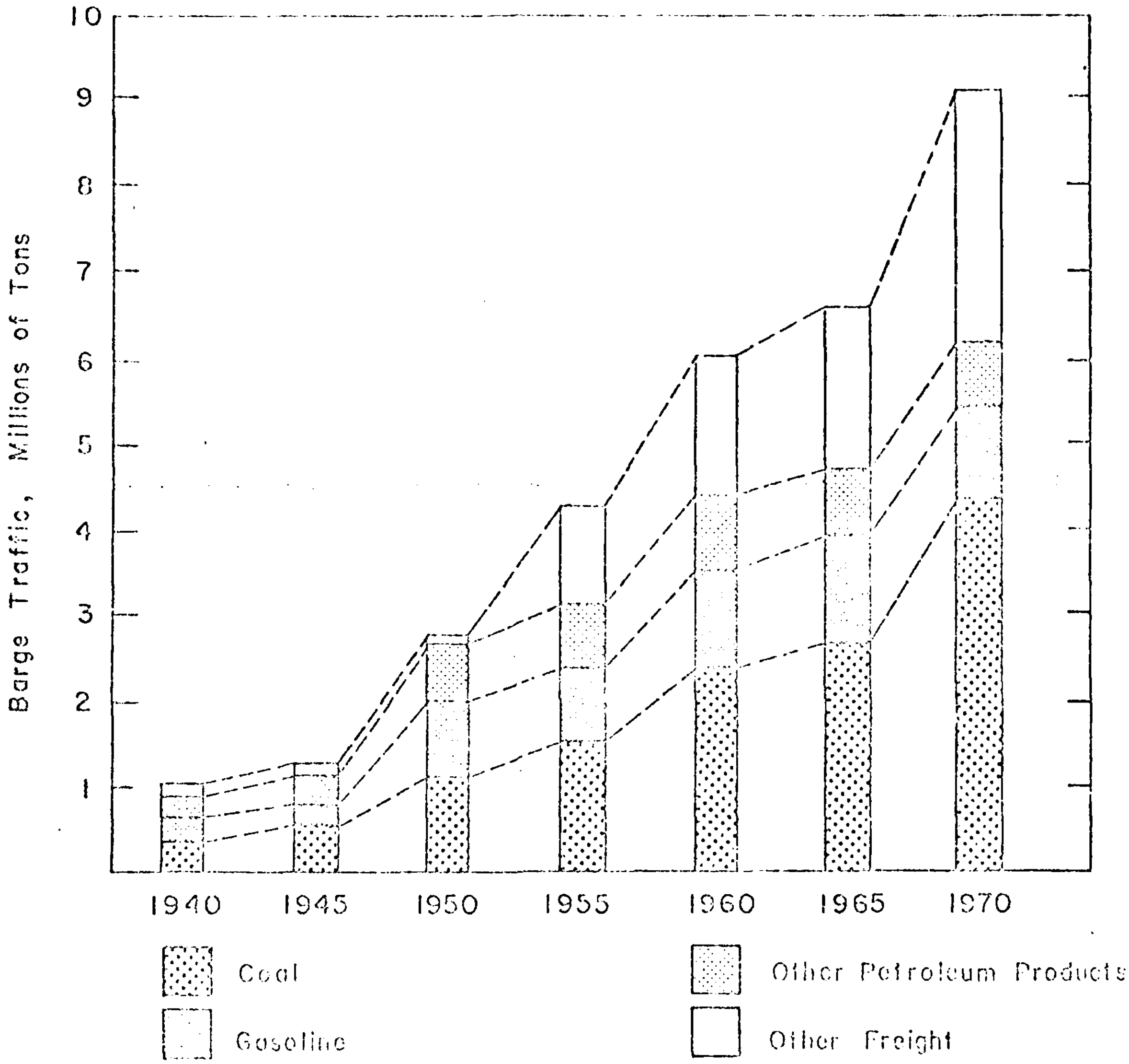

Figure 30. Receipts of Major Commodities -- All Ports, St. Paul District ([illegible] U.S. [illegible] Corps of Engineers, St. Paul District)

It is noteworthy that receipts into the St. Paul District have always exceeded shipments. In earlier years this imbalance was often extreme (e.g., 1953 receipts = 5,052,1[illegible] tons, shipments = 354,2[illegible] tons). Recently, however, the ratio has been about 2:1. Inasmuch as grains and soybeans constitute the preponderant tonnage of shipments, fluctuation in waterborne transport of these products can be profound due to crop conditions and storage facilities, foreign sales, and competing forms of transportation.

A comparative idea of shipping activity can be gained from the following information. Vessel traffic measured in tons from Minneapolis to the mouth of the Missouri River is shown for selected years as follows:

Year	Total Vessel Traffic (Tons)
1962	30,526,626
1964	34,108,482
1966	41,311,941
1968	46,174,929
1970	54,022,749
1971	52,773,097

Certain industries, depedent upon barge traffic for their economic viability have located on industrial sites along the river. The investment which they represent and the employment they generate are also attributable to the activities of the Corps of Engineers. Connected with this physical evidence of the Corps impact is the human impact perhaps best expressed in the employment which these facilities and vessels provide.

Analysis of commercial and industrial facilities adjacent to the St. Croix channel indicate that the major commodity [illegible] on the river is coal. The following table ([illegible] 1971) [illegible] the freight traffic on the St. Croix from 1962 through 1971.

Year	Tons	Year	Tons
1962	33,357	1967	323,024
1963	30,567	1968	1,344,850
1964	23,133	1969	1,319,305
1965	13,236	1970	1,209,681
1966	17,122	1971	1,194,995

Source: U. S. Army Corps of Engineers, 1971, Waterborne Commerce of the United States

An analysis of the traffic for 1971 is as follows:

Coal and Lignite	1,193,602 tons
Nonmetallic minerals	1,393
Total	1,194,995 tons

All of this terminated in the St. Croix River.

This barge activity is presently equivalent to about 120 trains per year, one train every three days, with an average capacity of 10,000 tons. The barge traffic eliminates the adverse impacts of noise and disrupted automobile traffic at railroad crossings that would come if rail transporation were used.

Statistics on the numbers of vessels originating or terminating on the St. Croix were given in Table 23 . Some idea of barge activity can be gained from studying the commercial docks on the river.

Commercial Dock Facilities. Firms that depend heavily on the river often maintain riverside facilities. The St. Croix River has three commercial docks and terminals, including one that serves Northern States Power. There is also some water-oriented [illegible] of interest. A boat yard and repair facility is located at Mile 22.5 on the right (Minnesota) bank and another boat works is located at Mile 18.1. There is an excursion boat the "Jubilee" which carries substantial numbers of passengers during the warmer months of the year. Behind some of these docks are factories and storage facilities that are dependent upon them. Thus, the ramifications of river navigation reach deeply into the entire economy of the region and indeed throughout the whole upper Mississippi. Employment directly and indirectly connected to these industries forms a small, but significant percentage of the regional work force.

From an economic point of view most of the effects of the activities of the Corps of Engineers are beneficial. Ultimately the benefits of economic activity have to be measured in terms of providing livelihood to human beings. Employment generated by the availability of waterborne transport to the St. Croix River includes both workers directly connected with the river itself and a far larger number of those whose livelihood is less directly dependent on water shipping. In the first category is included employment by the Corps of Engineers itself, workers on docks and shoreside facilities, and those working on the vessels themselves. The second category consists of those whose livelihood is gained by either utilizing the products brought into the St. Croix by waterborne carriers or who process goods shipped in by water. Included in this category are those who supply goods and services to those directly involved with water shipping on the upper Mississippi.

The total employment involved either directly or indirectly with all commercial operations on the river is not known. The Corps of Engineers itself has some 150 persons who are concerned with lock and dam operations. In addition to this the dredge "Thompson" has approximately 65 crew members. U. S. Department of Commerce data on employment on the St. Croix are deficient as well. These data are collected for mid-March, a period when water traffic in the St. Paul District is almost completely inactive and seasonal lay-offs are in effect. Further, these data are aggregated in a way designed to prevent isolation and identification of particular firms. This also has the effect of preventing identification of employment or other economic activity in particular pools or even of particular waterways. However, some estimates of employment can be made. In mid-March of 1971 8,632 persons in the U. S. were employed in River and Canal Transport.

This figure does not include warehousing or persons employed by firms where the SIC classification lies outside of transportation, even though they themselves may be working exclusively on the river. The same data show 556 persons in Minnesota as a whole who work in the field of water transport. This however, includes the Great Lakes as well as the Upper Mississippi. Some of these people are employed by private dredging firms whose existence is dependent upon the work of the Corps.

A further benefit which can be attributed to the maintenance of navigation on the St. Croix is in the savings in transportation costs, particularly for bulk commodities. Estimates of these savings have been made. One of these estimates is the savings over the other various least cost alternatives of between 4.0 and 5.4 mills per ton-mile (UMREBC, Study Appendix J, 1970). It is generally recognized that bulk commodities, particularly those having low value-to-weight ratios, are appropriate for barge transport. Coal and phosphates have these characteristics and are examples of such commodities that terminate on the St. Croix River.

The socioeconomic impact of the physical effects of navigation cannot be measured precisely because of the inability to isolate single factors from a wide-range of potential ones. Dredging and the movement of tugs and barges does increase water turbidity to which must be added pollution from barge spillage, washing and loss while loading or unloading. Yet this pollution may be small relative to the load placed in the river from other sources. These impacts may have adverse economic effects on recreational uses such as fishing and boating.

<u>Commercial Fishing</u>. Recent data on commercial fishing on the St. Croix are difficult to find. Commercial fishermen are active between Taylor's Falls and the mouth of the River. The catch is largely carp with an average annual catch between 1958 and 1965 of 399,000 pounds. Total employment in 1965 was 5 part-time commercial fishermen.

Recreational Impacts

Recreational impacts may be divided into boating activities and related facilities, sport fishing and hunting, and sightseeing and picnicking.

Observation indicates that pleasure boating is extensive. Over 98,000 man-hours were devoted to boating in 1968-69 (See Table 24 in Section 2).

A variety of physical facilities have been developed on the St. Croix that exist mainly to serve boaters using the pool. These include:

Facility	Number
Small boat barbors, marinas, boat clubs	6
Recreational sites	2
Commercial recreational sites	11

Except possibly for the beaches and recreational sites without ramps, which do not cater primarily to boaters, all of these facilities result from Corps' operations on the River that contributed the channel and stable water levels.

Over 25 recreational sites of various kinds have been identified. The relatively large number of recreational sites testifies to the importance of the river as a recreational resource and the utilization of its waters and shoreline. The number of commercial recreational sites as well as clubs, barbors, and marinas indicate the substantial economic activity of the river. It is apparent that this recreational usage coexists with the barge traffic and indicates multiple cooperative usage. It is probable that barge traffic is realtively infrequent on the river as indicated by the small numer of commercial docks and terminals.

Sport Fishing and Hunting. The data, which are available show the popularity of sport fishing on the St. Croix River in 1968-69, amounting to over 106,000 man-hours (See Table 24 in Section 2).

The rising water level of the St. Croix River due to d[illegible]ing of the Mississippi has increased the spawning areas for fish. In theory this offers the potential for more sport fishing. However, on the St. Croix this is probably partially offset by pollution and turbidity from increased industrial activity along the perimeter of the port and barge activity in it, although water quality is considered to be good.

The water levels on the St. Croix have been raised by Corps' operations which suggests the potential for lesser bird hunting and maybe a lessening of hunting opportunities for small animals. Increased industrialization and urbanization has operated to reduce this hunting potential. Unfortunately, no data were found that measures hunting activity in and adjacent to the River.

Sightseeing and Picnicking. Recreational sites along the shores of the St. Croix facilitate sightseeing, picnicking, and hiking. Non-boating visitors to these sites might be there whether Corps' operations existed on the Upper Mississippi or not. The use of these sites by small boats and canoes are not attributable to Corps' activities. However, the increased depth due to the Corps' channel assured safe navigation to the large cruisers.

Cultural Impacts

Sites of cultural interest do exist along the shores of the St. Croix River, but no effects at these sites are known at present to have been caused by the activities of the Corps of Engineers.

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4. UNAVOIDABLE ADVERSE EFFECTS

The nine-foot navigation project in Lake St. Croix may have unavoidably produced some adverse effects on the environment although basic information is lacking. The adverse effects are due mainly to increased water depth, maintenance dredging, commercial navigation and the development of the river bank for barge terminals and businesses.

Dredging denudes the river-bottom and increases turbidity. Turbidity may increase three-fold just downstream from the dredge and may be as much as double the "normal" unaffected turbidity nearly a mile downstream. The resuspended sediments causing the turbidity are deposited downstream where they may smother benthic organisms, fish and other [illegible] organisms, although data on the specific effects on these organisms is lacking.

Dredged spoil is placed on terrestrial and aquatic sites, causing loss of terrestrial and aquatic organisms. Dredge and spoil sites seem to take a decade or more before they are recolonized by some organisms.

Commercial development of the river bank has been stimulated by the navigation channel. These developments alter or remove the natural terrestrial and aquatic communities. The dredge spoil sites and commercial sites as well as homes and recreation sites, are probably centers of increased run-off and soil erosion, contributing to the sediment accumulation in Lake St. Croix. At the same time these commercial and spoil sites detract from the aesthetic quality of the Lake. Studies need to be made [illegible] the [illegible] of sediment and specific effects of sedimentation, dredging [illegible] the aquatic environment.

[illegible] to bank erosion. At the same time it also may detract from the aesthetic quality. Discharges and spills from vessels and barge terminals would also have a detrimental effect, particularly on the aquatic environment. However, studies are needed to determine the nature and extent of adverse effects of these effluents.

Other aspects of the nine-foot channel project possibly had adverse effects upon the natural environment of Lake St. Croix. Deepening of the lake submerged about 260 acres of floodplain, marsh and shallow-water areas, and about 100 acres of islands, but there are no data which describe the significance of this impact. Since these areas were limited in size prior to development of the nine-foot channel, it is possible that submergence of these areas may have been relatively important to existing plants and animals.

5. ALTERNATIVES TO [illegible] ACTIVITIES AND FACILITIES

There are several possible alternative methods of operating and maintaining the nine-foot channel project in the St. Anthony Falls pools. Since present adverse effects probably derive mainly from dredging and spoiling, attention is directed particularly to alternatives for channel maintenance.

Channel Maintenance

In order to reduce adverse effects of channel maintenance on the [illegible] St. Croix, several alternatives should be considered. First, the spoil should be barged to a central terminal for commercial use or inland disposal such as is done by private dredging companies. This would allow present spoil sites to revegetate and become natural or recreation sites.

Spoil and other bare-soil sites should be revegetated to reduce erosion due to rain and wind. Riprapping with derrickstone would reduce erosion due to the river current. Derrickstone would also improve the fish and benthos habitat.

Recreation along the shore and blufftop could be improved by making bicycle trails and foot paths. If, in addition, the appearance of commodity storage areas and businesses could be [illegible] or [illegible] removed, the aesthetics could be considerably enhanced. The natural scenic beauty of the St. Croix and its high recreational demand suggest that removal of industrial and commercial sites from the river [illegible] is especially important. Further improvement in aesthetics and [illegible] could result [illegible] the quality of the effluent from municipal treatment plants [illegible]. Reduction of soil erosion and of spills and discharges [illegible] and other sources also would help.

Improved water quality and river bank habitat probably would increase waterfowl, fish, turtles and other aquatic organisms.

Lock and Dam Operation

At present no alternatives are presented to lock and dam operation, except for increased frequency of lock operation or the construction of a ladder to facilitate fish and clam migration.

6. THE RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

Establishment of the nine-foot channel in Lake St. Croix brought economic and perhaps some recreational benefits to communities in the river valley, and the Metropolitan area as well. It also possibly benefited some animals, while possibly contributing to a reduction in biotic productivity. The project has altered productive natural habitat due to flooding and channel maintenance. Also the channel has stimulated urban development of the river bank, further altering or reducing natural habitat.

Short-Term Uses

Growth of river transportation has benefited segments of the economy. River-related jobs and businesses may help forge a broader-based economy upon which to develop future economic growth. A relatively large portion of the submerged and recreational banks and a smaller portion of the river bottom as well, are directly or indirectly influenced by commercial and recreational navigation in the Upper Reach of the Lake. Land-use practices in response to commercial navigation, and operation and maintenance of the nine-foot channel also may have altered the productivity of natural communities along and in Lake St. Croix. Thus, the aesthetic qualities and recreational aspects also have been altered.

Enhancement and Maintenance of Long-term Productivity

Development of commercial navigation in Lake St. Croix resulted in increased water depth and the dredging of a nine-foot deep channel, and in construction of a lock and a dam. The lock and dam may have had some detrimental effect on the biota, but also may have benefited the natural environment. A relatively small area of the river is occupied by the facilities, while an avenue (Lock 3) is provided for fish and clams and other benthos to by-pass Dam 3.

Creation and maintenance of the channel probably has disturbed the natural river habitats on or near the channel sufficiently to alter biotic productivity. Dredging or spoiling of a site requires ten or more years to be repopulated. Continued distrubance possibly may alter the physical environment sufficiently to extend this time.

Alternative land-use and maintenance practices could conceivably shorten the time necessary to repopulation of a site and may hasten the return of high biotic productivity. Set-back of the businesses and terminals, except for the actual loading-unloading facilities, and a central spoil disposal site could complete a green belt along both banks of the Upper Lake. These and other erosion and sedimentation control measures probably could significantly reduce the adverse effects of the nine-foot navigation project and related activities on the enhancement and maintenance of the long-term productivity in Lake St. Croix.

Resource Implications for Socioeconomic Activities

Table 33 summarizes the major resource implications of continuing to operate and maintain the nine-foot channel in the St. Paul District. Resource implications, i. e., the costs and benefits of the project, for the industrial, recreational and cultural components of the socioeconomic system are discussed in sequence below.

Corps Operations

Table 33 identifies the major effects [illegible] with lock and dam operation and dredging operations. These include employment in lock and dam and dredging operations, maintenance of relatively stable water levels in each look, and the presence of a navigable nine-foot channel in the St. Paul District. About 150 people [illegible] involved with lock and dam operations in the district and about 75 with [illegible] operations; thus about 225 people derive jobs [illegible] directly [illegible] Corps' operations. The annual direct cost to taxpayers for lock and [illegible] operations is $2,601,000 (for the year 1970) and for dredging operations is $1,[illegible],000. Specific environmental costs of the stable water levels in the pools and the nine-foot channel in the St. Paul District [illegible] increase in sedimentation behind dams and wing dams and [illegible] reduction in fish and wildlife habitat due to improper dredge spoil placement.

Industrial Activities

As summarized in Table 33, the major [illegible] Corps [illegible] on industrial activities are for barge operations, commercial dock operations, and commercial fishing. Table 33 notes that there are employment implications for each of these three activities but these benefits must be balanced against accompanying increases in sedimentation, turbidity, and possibly other pollution in the river.

Of special importance in the current energy crisis are the answers to two questions that relate to barge transportation: How effective is barge transportation relative to other modes of transportation relative to other modes of transportation with respect to:

1. Energy usage?
2. Air pollution?

Because the answers [illegible] Upper Mississippi River, these [illegible] questions [illegible] detail. In addition [illegible] are discussed.

Table 33. First-Order Benefits and Costs to Socioeconomic Activities of Maintaining the Nine-foot Channel in Lake St. Croix

Socioeconomic Activity		Qualitative Summary of Socioeconomic Benefits and Costs	
General Category	Specific Activity	First-Order Socioeconomic Benefits	First-Order Socioeconomic Costs
Corps Operations	Lock and dam (L/D) operation	1. L/D employment 2. Stable water levels	1. Cost of L/D operation 2. Sedimentation behind dams and at head of flatwater pool
	Dredging Operations	1. Dredging employment 2. Nine-foot channel	1. Cost of dredging operation 2. Destruction of fish and wildlife habitat because of improper dredge spoil placement.
Industrial	Barge operation	1. Barge employment 2. Low-cost water transportation 3. Energy saving compared to alternate transportation modes 4. Decrease in air pollution compared to other modes.	1. Increased river turbidity 2. River pollution from oil and gasoline from barges 3. Hazard to small craft
	Commercial Dock	1. Dock employment 2. Attraction of barge-transportation-oriented firms that provide local employment	1. Increased river pollution from industrial activities along shore 2. Loss of riverfront property for recreational use
Recreational	Boating Activity	1. Increased safety of deeper channel for boaters 2. Provided relatively quiet water which is excellent for rowing clubs.	1. Decline in aesthetic appeal of riverscape
	Sport Fishing	1. Initially increased habitat for fish	1. Increased sedimentation in fish habitat 2. [illegible] of wing dams and [illegible]

Table 33. First-Order Benefits and Costs to Socioeconomic Activities of Maintaining the Nine-Foot Channel in Lake St. Croix (Continued)

Socioeconomic Activity		Qualitative Summary of Socioeconomic Benefits and Costs	
General Category	Specific Activity	First-Order Socioeconomic Benefits	First-Order Socioeconomic Costs
Recreational (cont.)	Birdwatching	1. Initially increase habitat for waterfowl	1. Decreased waterfowl habitat from improper dredge spoil placement 2. Decrease in songbird habitat with removal of trees and brush, and joining of islands for industrial usage
	Sightseeing, picnicking, [illegible]	1. Increased number of potential swimming areas.	1. Decreased opportunities for miscellaneous recreational activities 2. River pollution from industrial and barge operation 3. Decrease in aesthetic appeal of river
Cultural	Contemporary	1. Provided channel so that the Centennial Showboat can be docked at the University of Minnesota "River Flats".	

<u>Barge Transportation and Energy Usage</u>. Effective energy utilization is particularly important due to the present (and probably continuing) energy crisis. It also affects air pollution which relates directly to transportation energy consumption.

At present transportation utilizes about 25 percent of the total U. S. energy budget for motive power alone. This usage has been increasing at an average annual rate of about 4 percent per year.

In comparing the efficiency of energy utilization between various transportation modes the term "energy intensiveness" is commonly used. Energy intensiveness is defined as the amount of energy (in BTU's) needed to deliver one ton-mile of freight. The following table compares the energy intensiveness of various modes of freight transportation ([illegible], 1975):

Freight Mode	Energy Intensiveness (BTU's/ton-mile)	Ratios of E.I.
Waterways	500	1
Rail	750	1.5
Pipeline	1,850	3.7
Truck	2,400	4.8
Air Cargo	63,000	126

It is apparent from this table that motive energy is utilized more efficiently in water transportation than through any other mode of freight transportation. Therefore, under conditions of restricted petroleum or [illegible] availability the use of barging whenever feasible [illegible]. Indeed, an increased use of the Upper Mississippi and its tributaries is likely. Influencing this will be increased shipments of [illegible] of the [illegible] District and increased imports of coal and petroleum products into the region. Exports of grain to other countries and shipments of other parts of the U. S. are expected to increase. Energy demands in the Upper Midwest are also expected to rise. In addition freight which is now only marginally involved in barging may shift from other forms of transportation to the less energy-intensive forms. This shift may also be expected to change existing concepts of the kinds of freight suitable for barging with consequent impact on storage facilities. In many cases economic trade-offs may exist between the mode of transportation and the size of inventories considered to be suitable. If the energy costs rise sufficiently, increased capital necessitated by use of the slower-moving barge transportation and tied up in inventory and in storage space may be justified. If this occurs, other kinds of cargoes presently shipped by rail or truck or pipeline may be diverted to barge.

In addition to energy conservation, the importance of the Upper Mississippi as a transportation artery is shown by the burden which would be placed on the rail system (as the major alternative transportation mode used to move heavy, high-bulk commodities) in the absence of barge traffic on the river. In 1972 an estimated 16,361,174 tons of various commodities were received and shipped from the St. Paul District. Under the simplifying assumption that the average box or hopper car carries 50 tons, this amounts to the equivalent of 327,223 railroad cars or some 3,272 trains of 100 cars each or approximately nine trains each day of the year.

Barge Transportation and Air Pollution. Barge transportation also results in less air pollution per ton-mile than either rail or truck modes. Diesel engines are the most common power plants used by both towboats and railroads. A large percentage of over-the-highway trucks use diesel engines as well. The diesel engine is slightly more efficient than the gasoline engine due to its higher compression ratio. Thus, [illegible] to move one ton of freight one mile by diesel than by gasoline engines. [illegible] truck, as we have seen. Consequently a smaller amount of fuel is required to move freight. With less fuel used, air pollution is reduced.

The amount of air pollution caused by either diesel fuel or gasoline varies substantially only in the type of air pollution. The following table illustrates these pollution effects (U.S.P.H.S., 1968):

Type of Emission	Emission Factor: Pounds/1,000 gallons diesel fuel	Emission Factor: Pounds/1,000 gallons gasoline
Aldehydes (R-CHo)	10	4
Carbon monoxide (Co)	60	2300
Hydrocarbons (C_xH_y)	136	200
Oxides of Nitrogen (NO_2^-)	222	113
Oxides of Sulfur (SO_2^-)	40	9
Organic Acids (acetic)	31	4
Particulates	110	12

Based upon the energy intensiveness ratios shown earlier, a diesel train will produce 1.5 times as much air pollution and a diesel truck 4.3 times as much air pollution per-ton-mile as a tug and barges. In any event, no matter which kind of pollutant is of concern in a particular case, the efficiency of barging compared with other modes of freight transportation will result in reduced air emissions per ton-mile.

<u>Barge Transportation and Cost Savings</u>. A further benefit which can be attributed to the maintenance of navigation on the Upper Mississippi is in the savings in transportation costs, particularly for bulk commodities. Estimates of these savings have been made. One of these estimates the savings over the other various least cost alternatives of between 4.0 and 5.4 mills per ton-mile ([illegible], 1970). It is generally recognized that bulk commodities, particularly those having low value-to-weight ratios, are appropriate for barge transport. Coal, petroleum, and grain that [illegible] are examples of such commodities that originate, terminate, or move through the St. Paul District pool on river barges.

Recreational Activities

Table 33 identifies the variety of recreational activities -- from boating and sport fishing to sightseeing and camping -- that may be helped or hindered by Corps' operations. Ideally it would be desirable to place dollar values on each of the benefits and costs to the recreational activities cited in Table 33 to weigh against the benefits of barge transportation made possible by maintaining the nine-foot channel. Unfortunately both conceptual problems and lack of precise data preclude such an analysis. The nature of these limitations can be understood by (1) looking initially at a theoretical approach for measuring the benefits and costs of recreational activities and (2) applying some of these ideas to the measurement of only one aspect of all recreational activities -- sport fishing.

Benefits and Costs of Recreational Activities. Theoretical frameworks exist to perform a benefit-cost analysis of recreation or tourism activity. One example is a study prepared for the U. S. Economic Development Administration (Arthur D. Little, Inc., 1967). Unfortunately even this example closes with a "hypothetical benefit-cost analysis of an imaginary recreation/tourism project" that completely neglects the difficulty of collecting the appropriate data.

Applying even this theoretical framework to the nine-foot channel project presents both conceptual and data collection problems. For example, continuing to operate and maintain the nine-foot channel may hurt sport fishing because of the reduction in fish habitat. This means that the total value of sport fishing in the river should not be considered in the analysis. Rather, only the incremental increase or decrease in sport fishing attributable to present Corps' operations (not due to the initial lock and dam construction) should be weighed against those operations; no estimates are presently available to assess the effect of current Corps' operations on fish and wildlife. Also reduced fishing and waterfowl habitat may eventually become an increased terrestrial habitat. What the fisherman loses the hunter, trapper, or bird-watcher may gain.

This raises a second difficulty: how does one measure the total value of sport fishing on the river in order to start to measure the incremental portion attributable to Corps' operations? For sport fishing various measures have been identified, each having its own drawbacks (Glasson and Foetsch, 1966): gross expenditures by the fisherman, market value of fish caught, cost of providing the fishing opportunity, the market value as determined by comparable privately owned recreation areas, and the direct interview method -- asking fishermen what hypothetical price they would be willing to pay if they were to be charged a fee to fish.

If some average price per fisherman or trip were available, it still would be possible to assess the total value of sport fishing in the study area only if estimates of the number of sport fishermen or number of sport fishing trips were available. In the St. Paul District these estimates are available through sport fishery surveys for only three pools: Pool 4, Pool 5, and Pool 7. The most recent data available for these pools are for the 1967-68 year (Wright, 1970); comparable data for 1972-73 have been collected but are not expected to be published in report form until about December, 1973.

Valuing Sport Fishing in the Study Area. A variety of studies have been done on recreation and tourism in Minnesota and the Upper Midwest during the past decade (North Star Research Institute, 1966; Midwest Research Institute, 1968; [illegible], et al., 1969). For purposes of analyzing sport fishing and other recreational activities on the Upper Mississippi River, however, they have a serious drawback; these studies are generally limited to recreationists who have at least one overnight stay away from home. In the case of the St. Paul District, with the exception of campers and boaters on large pleasure craft with bunks and virtually all river users are not away from home overnight and are omitted from such studies.

Information is then generally restricted to that available in the USFWS sport fishing studies such as those shown below for 1967-68 (Wright, 1970):

Pool Number	Total Number of Fisherman Days	Value at $5.00 Per Trip[a]	Value at $1.50 Per Trip[b]
4	169,361	$846,805	$254,042
5	51,786	258,930	77,6[illegible]
7	63,238	316,190	94,857

[a] Based on data reported in the "1965 National Survey of Fishing and Hunting" that the average daily expenditure for freshwater sport fishing was $4.9[illegible] per day.

[b] Based on data in Supplement No. 1 (1964) to Senate Document 97 that provides a range of unit values of $0.50 to $1.50 a recreation day for evaluating freshwater fishing aspects of water resource projects.

Thus the sum of the values of sport fishing given above for these three pools varies from about $0.4 million to $1.4 million depending upon the valuation of a fishing trip. Assuming one of these values were usable, the researcher is still left with the task of determining the portion (either as a benefit or cost) of Corps' operations. With the limited funds available for the present research and the limited existing data, detailed analysis is beyond the scope of the present study.

Similar problems are present in evaluating the other recreational activities in the study area.

Cultural Sites

No [illegible] in the present study to [illegible] on archaeological, historical, or cultural sites damaged or enhanced by Corps' operations. Rather, such sites have merely been identified, where existing data permit.

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7. IRREVERSIBLE COMMITMENTS

The construction of navigation facilities and continuing channel maintenance, as well as the barge traffic and terminal facilities which followed in Lake St. Croix required the irretrievable commitment of human and natural resources.

Cement, steel, lumber and fuel (and also the natural resources from which these are derived), plus labor and financial were consumed in the construction of the Lock and Dam 3 and appurtenant structures. Some of the steel possibly could be retrieved as scrap.

There also is a continuing commitment of labor, fuel and financial resources in the operation and maintenance of these facilities.

The annual maintenance dredging of the nine-foot channel in Lake St. Croix consumes fuel, labor and financial resources. Some steel and other structural materials are committed via the dredging equipment, some of which eventually may be salvageable.

Some of the natural habitats in and along the river are irreversibly committed to the nine-foot channel project and attendant activities. Dredging, and siting of the locks and dam removed or altered river bottom and river bank communities. Additional river bank communities were altered or removed due to barge terminals, which are dependent upon the navigation. The extent of this removal or alteration is not known [illegible] [illegible]. However, it [illegible] [illegible] due to dredging operations [illegible].

The decrease in natural habitats and concomitant increase in urbanization in Lake St. Croix has irretrievably diminished some portions of this section of the river as a natural, aesthetic and recreational resource to the citizens of the St. Croix Valley and, indeed, to the whole Metropolitan Area.

8. RECOMMENDATIONS

Several studies should be conducted to better define the beneficial and adverse effects, and methods to reduce the latter, of the nine-foot channel project in Lake St. Croix.

Most important are studies of the erosional sources of sediment and of dredging and spoiling operations. Efforts should be directed to locating and stopping (or at least reducing) the influx of sediment into Lake St. Croix. A reduction in sediment inflow would, of course, reduce the need for dredging and spoiling, thus reducing adverse environmental effects.

At the same time alternative methods of dredging and spoiling should be investigated.

A noticeable reduction in adverse environmental effect probably could be obtained if spoil disposal was centralized. From this point on-land disposal would be more efficient, such as at erosion site or sanitary landfills. A further study of the potential market for dredge spoil, indicated by a preliminary study conducted by the Bureau of Sport Fishery and Wildlife, might reveal an economic return from centralized disposal.

Since not much is unknown about the natural communities of the bluffs and lake, particularly in the lower part Lake St. Croix, studies should be made with an assessment of the degree of sensitivities to dredging and spoiling operations. Coordinated studies [illegible] present spoil sites for aquatic and [illegible] measures would also provide protection [illegible] spoil bank into the river. Further, [illegible] spoil bank revegetation and enhancement. The Corps acting in cooperation with other agencies probably could make significant contributions to the improvement and maintenance of man's environment.

Spoil should be deposited so that there are low areas between spoil mounds in the manner shown in Figure 31. Vegetation would grow more quickly in these low areas and provide protection from wind and water erosion because of their orientation. The diked area would provide protection from current in an area maintained to provide off-channel beaching of pleasure craft.

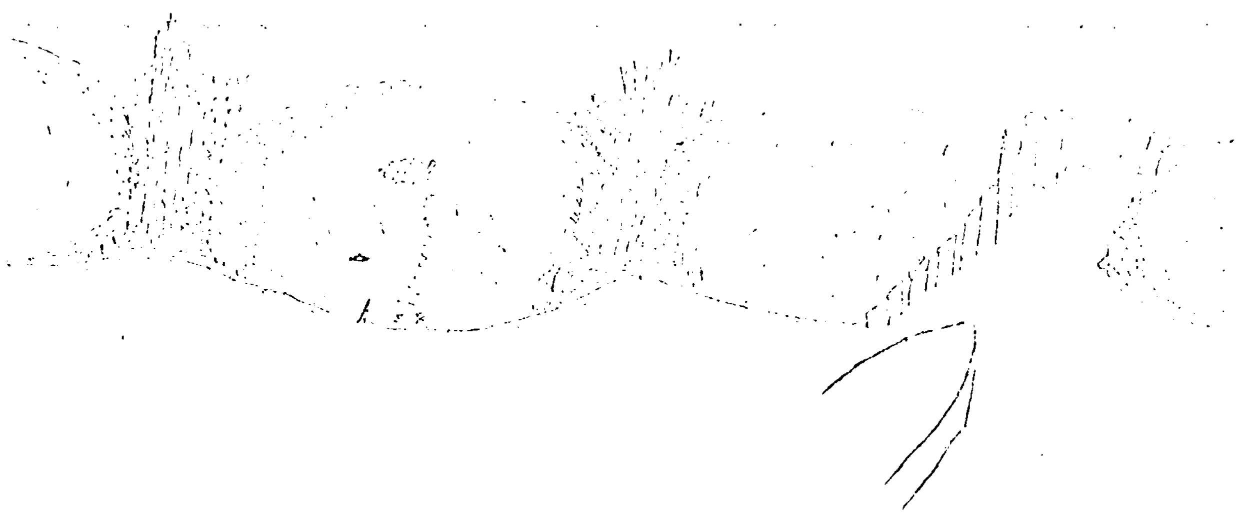


Figure 31. Recommended Alternative Method of Revegetating Spoil Sites. The Screens of Vegetation Are Perpendicular to the Current (C[illegible] [illegible])

9. APPENDIX A: NATURAL SYSTEMS

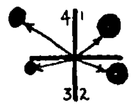
I. METHODS OF DATA COLLECTION

Methods for Collecting Samples

Biological Measurements

Benthic organisms were samples using Petersen or Ekman dredges along standard and special transects. Vegetative cover, in acres was determined by planimetry from aerial photos in a study currently conducted by the Department of Forestry, University of Minnesota. Abundance of plant species was determined in one meter square quadrats (for herbs and vines) and by point-quarter techniques (for trees, vines and shrubs) (Cox, 1967).

QUADRAT
percent cover
of each species
reported



POINT QUARTER
percent frequency
of tree species
reported

Measurement of Physico-chemical Parameters

Temperature was measured using a thermister and a Precision Scientific Instruments meter, standardized to a precision mercury thermometer (APHA et al., 1971).

Dissolved oxygen was measured using a galvanic cell-type probe and a Precision Scientific Instruments meter, standardized to the Winkler titration, azide modification (APHA et al., 1971)

Turbidity was measured by nephelometry using a Horizon Ecology, Inc. Model 104 nephelometer (APHA et al., 1971).

Water depth was measured with sonar using a Heathkit Electronics Company Model MI-101-2.

II. MAP OF ST. CROIX RIVER AND TRANSECT LOCATION

The map of St. Croix River (Figure 1) shows the location of sampling stations along "standard" and "special" transects. Standard transects are surveyed lines which cross the river at a right angle in each pool and are chosen to sample its broad environmental diversity. They extend from bluff to bluff and include bluff slope, river banks, marsh, open river and river bottom (See Figure 2). However, on long transects most of the sampling effort will be concentrated on the smaller area between the railroad tracks on each side of the river. Standard transect SAA is located about 0.2 mile upstream from the head of navigation (Mile 24.5). This is the area most river-like and perhaps least modified by impoundment; transect SBB is located near the mid-length of the lake (Mile 12.3); and transect SCC is located 0.7 mile upstream from the mouth of Lake St. Croix, at Prescott, Wisconsin.

Similarly, special transects (SXX-Mile 16.6 and SYY-Mile 6.4) were used to study features of particular interest, such as spoil sites and the mouths of major tributaries. The azimuth (compass direction, using N as 0 and E as 90 degrees) and other pertinent data is given in Table 1.

Sampling stations were located along these transects, mainly in the middle of a type of habitat such as shallow stump field, deeper river channel, woods, field or bare sandy spoil.

In order to gather more detailed information within some habitats, "secondary" transects were located perpendicular to the standard or special transects. Sampling stations were located randomly along these secondary transects.

Sampling Frequency

Field data to corroborate and expand the aerial survey of the terrestrial vegetation was completed in October.

Figure 1. Map of Lake St. Croix Showing Environmental Setting and Transect Locations (USGS, 1967)

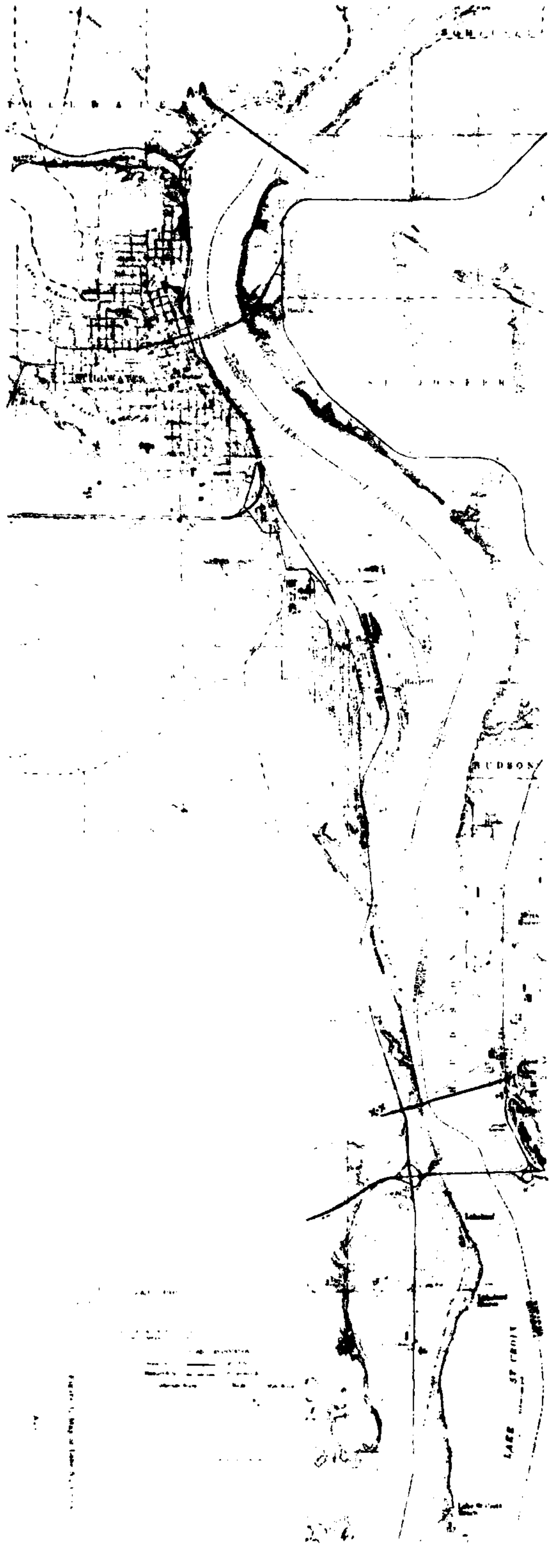


Figure 1. Map of Lake St. Croix Showing Environmental Setting and Transect Locations (USGS, 1967) (Continued)

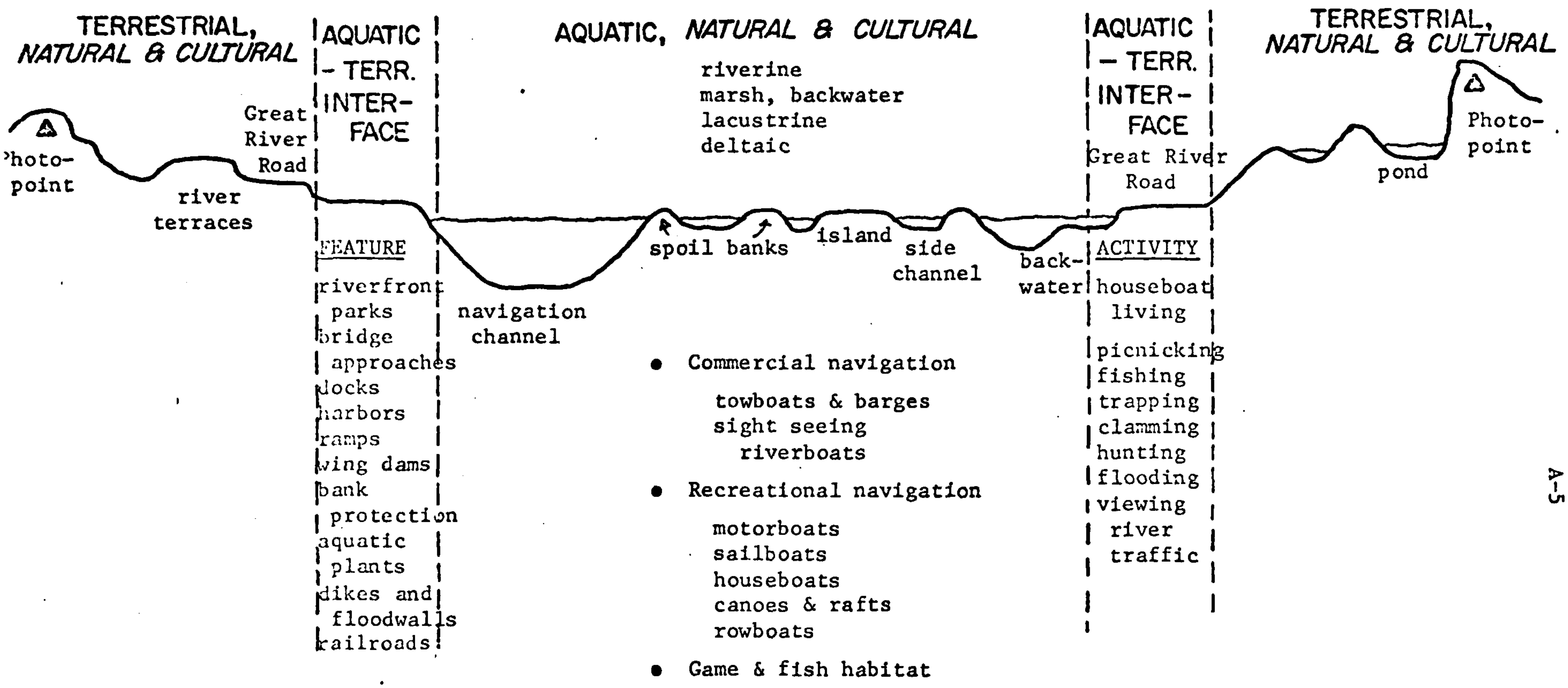


Figure 2. Profile of a Typical Transect of the Marsh Portion of a Typical Pool.
Note that the figure also lists the various environmental features that may be found at various places along the transect.

Source: ESD - North Star --Gudmundson, 1972

Table 1. Description of Transects.

Pool; Pool Length	Transect Designation	River Mile Above Cairo, IL	Azimuth	Transect Length in Miles	Azimuth target, Location
USAF 3.6	Standard Transect UAA	858.9	86°	.15	SW corner of Minneapolis Water Works Bldg.
	Standard Transect UBB	855.7	278°	.13	Line up downstream legs of tower for high voltage line.
	Standard Transect UCC	854.4	52°	.31	Line up with D/S face of old limestone apt. bldg.
LSAF 0.6	Standard Transect LBB	853.4	175°	.15	Mooring cell ladder on R/B nearest lower L/D.
Pool 1 5.7	Standard Transect 1AA	853.1	28°	.15	Center of high-rise apt. bldg. on R/B.
	Special Transect 1XX	851.1	39°	.21	Gov't. daymark Mile 851.1; on spoil on L/B
	Standard Transect 1BB	850.6	46°	.15	Vertical seam on Platteville L.S. on left bluff
	Special Transect 1YY	849.4	99°		Oval pipe opposite; on R/B spoil downstream from Lake St. Bridge. Mid-stream azimuth 35° to WMIN radio tower, L/B.
	Standard Transect 1CC	848.0	86°	.20	Line up downstream face of high-rise apt. tower on L/B (720 River Terrace).
Pool 2 32.4	Standard Transect 2AA	847.4	263°	.15	Chimney on north wing (with white,round porch of MN Soldiers' Home Bldg.
	Standard Transect 2BB	831.7	264°	1.10	Gov't. (USCG) daymark Mile 831.7 R/B
	Special Transect 2YY	821.3,R	54°	1.10	Tall smokestack right of L/B water tower; transect runs from mid-channel to R/B, sampled by Hokanson in 1964.
	Standard Transect 2CC	815.5	52°	1.00	Tip of peninsula which extends 0.35 mi. upstream 4D #2.
	Special Study Area	833.2,R	54°	--	Mi. 833.1 Gov't daymark, 22?-yr-old R/B spoil site
	Special Study Area	832.0,L	256°	--	Tower for high voltage line on R/B, 8?-yr-old spoil site 4B.
	Special Study Area	827.7,R	85°	--	Gov't daymark Mi. 827.7, 2?-yr-old spoil site
Minn. R. 26.4	Standard Transect MAA	M24.8	347°	1.00	Second bend above Shakopee (US 169) Bridge
	Standard Transect MBB	M13.0	335°	1.05	Gov't. daymark, Mile 12.5
	Standard Transect MCC	M3.0	128°	.90	Gov't. daymark, Mile 2.9
St. Croix River 25.0	Standard Transect SAA	SC24.8	305°	.50	White bldg., right bank.
	Special Transect SXX	SC16.6	85°	.50	Upstream edge of bldg. at Lakefront Park.
	Standard Transect SBB	SC12.3	111°	1.05	Road coming down bluff to beach.
	Special Transect SYY	SC 6.4	291°	.38	Shallow dip in tree line on right bank
	Standard Transect SCC	SC 0.7	85°	.90	Fence marking upstream boundary of public beach on left bank.

Benthic samples were collected in April and May and again in August and September. Water quality data were collected in September and early November.

III. SUMMARY OF DATA COLLECTION POINTS AND TIMES

Benthic (bottom) grab samples were taken on standard and special transects during the months of April and May and in August. Sediments were washed out using a 707 micron standard mesh screen, and organisms preserved. Identifications were made by Mr. David Maschwitz, graduate student in the Department of Entomology, Fisheries and Wildlife, University of Minnesota.

The width of vegetation zones intersected by the transects was measured and one meter square quadrats and/or point quarter stations were used to determine the abundance of plant species. Plant species identifications were made in the field, and checked by Dr. Gerald Ownby, Curator of the Herbarium, Department of Botany, University of Minnesota.

Field data and pertinent data from the literature are presented on data sheets in Appendix A,IV.

IV. DATA SHEETS

Table 1. Abundance of Plants Found in the River Valleys, 1973.

Table 2. Partial List of Plants (BOR, 1972).

Table 3. Vegetation of Floodplain and Bluff Habitats (Cooper, 1947).

Table 4. Vegetation of Spring Lake Area (Leisman, 1959).

Table 5. Checklist of Mammals.

Table 6. Birds of the Minneapolis-St. Paul Area (Dodge, *et al.*, 1971).

Table 7. Checklist of Birds (Goddard).

Table 8. Summary of Chemical Analyses (NSP, 1971).

Table 9. Downstream Profile of Turbidity and the Effect of Dredging and Navigation, 1973.

Table 10. Plankton Algal Species (NSP, 1971).

Table 11. Attached Algal Species (NSP, 1971).

Table 12. Benthic Animal Abundance, 1973.

Table 13. Macroinvertebrate animals (NSP, 1971).

Table 14. Fish in Lake St. Croix (Krosch, 1972).

Table 15. Estimated Sport Fishing Catch (Krosch, 1970).

Figure 1. Annual Volume of Sediment Dredged Within Each River Mile, Arranged by Decade.

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area

(P - present; M - moderate; D - dominant)

Pool:	SAF Upper			SAF Lower	1			2			Minn. River			St. Croix River			
Species / Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
Trees and Shrubs																	
ACERACEAE																	
Acer negundo Box elder	P	P	P	P	P		P		P	P	P	P					
Acer nigrum Black maple																	
Acer rubrum Red maple					P												
Acer saccharinum Silver or soft maple							P					P		P		P	
Acer saccharum Sugar or hard maple						P	P							P			
Acer spicatum Mountain maple																	
Acer sp. Maple													P				
ANACARDIACEAE																	
Rhus glabra Smooth sumac				P	P												
Rhus radicans Poison ivy																	
Rhus typhina Staghorn sumac						P									P		P

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

	SAF										Minn.			St. Croix			
Pool:	Upper			Lower	1			2			River			River			
Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
Trees & Shrubs (cont'd.)																	
BETULACEAE																	
Alnus incana Speckled alder																	
Betula papyrifera Paper birch							P			P				P	P	P	P
Carpinus caroliniana Blue beech or hornbeam																	
Ostrya virginiana Ironwood or hop hornbeam				P						P						P	
CAPRIFOLIACEAE																	
Diervilla lonicera Bush honeysuckle																	
Lonicera prolifera Grape honeysuckle																	
Lonicera tatarica Tartarian honeysuckle										P							
Sambucus canadensis Common elder														P			
Sambucus pubens Red-berried elder				P		P											
Symphoricarpos occidentalis Wolfberry																	
Symphoricarpos orbiculatus Coralberry																	
Viburnum cassinoides Wild raisin																	
CELASTRACEAE																	
Celastrus scandens Climbing bittersweet																	

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Pool:	SAF Upper			SAF Lower	1			2			Minn. River			St. Croix River			
Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
<u>Trees & Shrubs (Cont'd.)</u>																	
CORNACEAE																	
Cornus alternifolia Alternate-leaved dogwood																	
Cornus racemosa Panicled dogwood																	
Cornus stolonifera Red-osier dogwood																	
CUPRESSACEAE																	
Juniperus virginiana Red cedar										P						P	P
Thuja occidentalis White cedar																	
FABACEAE (LEGUMINOSAE)																	
Amorpha fruiticosa False indigo							P										
Robinia pseudo-acacia Black locust							P			P							
FAGACEAE																	
Quercus alba White oak																	
Quercus macrocarpa Bur oak or mossycup oak															P		
Quercus borealis Northern red oak							P			P						P	P
Quercus velutina Black oak															P		
Quercus sp. Oak																P	

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

	SAF																
Pool:	Upper			Lower	1			2			Minn. River			St. Croix River			
Species / Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
Trees & Shrubs (Cont'd.)																	
JUGLANDACEAE																	
Carya cordiformis Bitternut hickory			P				P										
LEGUMINOSAE: see FABACEAE																	
MORACEAE																	
Morus rubra Red mulberry						P											
OLEACEAE																	
Fraxinus nigra Black ash												P	P				
Fraxinus pennsylvanica var. *subintegerrima* Green ash			P			P	P										
Fraxinus sp. Ash	P			P	P					P				P	P	P	P
PINACEAE																	
Larix laricina Tamarack																	
Picea canadensis White spruce																	
Pinus resinosa Red pine															P		
Pinus strobus White pine																P	

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Species	Pool:	SAF Upper			SAF Lower	1			2			Minn. River			St. Croix River			
	Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
<u>Trees & Shrubs (Cont'd.)</u>																		
ROSACEAE																		
Amelanchier huronensis Service-berry, Shadbush)																		
Amelanchier spp. Juneberry																		
Crataegus spp. Thorn-apple																		
Physocarpus opulifolius Ninebark																		
Prunus americana Wild plum																		
Prunus pensylvanica Pincherry																		
Prunus serotina Black cherry											P							
Prunus virginiana Choke-cherry								P										
SALICACEAE																		
Populus deltoides Cottonwood		M	D	P	P	P		P	P		P	P		P		P	P	P
Populus grandidentata Bigtooth aspen								P			P							
Populus balsamifera Balsam poplar																		P
Populus tremuloides Quaking aspen		P																P
Populus sp. Aspen		P																

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

	SAF																
Pool:	Upper			Lower	1			2			Minn. River			St. Croix River			
Species Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
<u>Trees & Shrubs (Cont'd.)</u>																	
SALICACEAE (Cont'd.)																	
Salix alba White willow						P											
Salix amygdaloides Peach-leaved willow		P				P								P			
Salix humilis Small pussy-willow																	
Salix interior Sandbar willow					P	P	P	P		P	P	P	P		P	M	
Salix nigra Black willow																	
Salix spp. Willows																	
TAXACEAE																	
Taxus canadensis Yew														P			
TILIACEAE																	
Tilia americana American basswood						P	P							P			P
ULMACEAE																	
Celtis occidentalis Hackberry			D														
Ulmus americana American elm	P		P	P	P	P	P		P			P		P			
Ulmus pumila Dwarf elm	P		P	P		P											

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Pool:	Upper			Lower	1			2			Minn. River			St. Croix River			
Species / Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
Trees & Shrubs (Cont'd.)																	
ULMACEAE																	
Ulmus rubra Slippery elm			P	D		P											
Ulmus sp. Elm	P				P					P					P	P	P
Vines (lianas)																	
VITACEAE																	
Parthenocissus quinquefolia Virginia creeper	P	P		P	P	P	P						P				
Vitis riparia Riverbank grape	P	D			P		P		P			P			P	P	
Herbs																	
AIZOACEAE																	
Mollugo verticillata Carpetweed																	
ALISMACEAE																	
Sagittaria sp. Arrowhead																	
AMARANTHACEAE																	
Amaranthus tamarincus (or tuberculata) Amaranth	P				P			P				P					
APOCYNACEAE																	
Apocynum androsaemifolium Dogbane							D										

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Pool:	SAF Upper			SAF Lower	1			2			Minn. River			St. Croix River			
Species / Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
<u>Herbs (Continued)</u>																	
ARACEAE																	
Arisaema triphyllum Jack-in-the-pulpit																	
Spathyema foetida Skunk cabbage																	
ARALIACEAE																	
Aralia nudicaulis Wild sarsaparilla																	
Panax quinquefolius Ginseng																	
Panax trifolius Dwarf ginseng																	
Hedera helix English ivy				P													
ARISTOLOCHIACEAE																	
Asarum canadense Canadian wild ginger														P			
ASCLEPIADACEAE																	
Asclepias exaltata Tall milkweed																	
Asclepias ovalifolia Oval-leafed milkweed																	
Asclepias syriaca Common milkweed					P	P	P										
Asclepias tuberosa Butterflyweed																	
Asclepias verticillata Whorl-leaved milkweed																	

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

	SAF Upper			SAF Lower	1			2			Minn. River			St. Croix RIver			
Species Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
Herbs (Continued)																	
BALSAMINACEAE																	
Impatiens sp. Jewelweed										P				P	P		P
BORAGINACEAE																	
Hackelia virginiana Beggar's lice																	
Lappula redowskii Stickseed																	
Lithospermum canescens Puccoon, Indian-paint																	
Lithospermum carolinense Puccoon																	
Lithospermum incisum Puccoon																	
Onosmodium molle Marble-seed, False gromwell																	
Myosotis sp. Forget-me-not														P			
CAMPANULACEAE																	
Campanula rotundifolia Harebell																	
Lobelia sp. Lobelia														P			
CAPPARIDACEAE																	
Polanisia trachysperma Rough-seeded clamyweed								P									

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Pool:	SAF Upper			SAF Lower	1			2			Minn. River			St. Croix River			
Species / Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
<u>Herbs (Continued)</u>																	
CAPRIFOLIACEAE																	
Triostevm perfoliatum Horse-gentian																	
CARYOPHYLLACEAE																	
Cerastium arvense Field chickweed																	
Cerastium nutans Nodding chickweed																	
Cerastium vulgatum Common mouse-ear chickweed														P			
Saponaria officinalis Soapwort, Bouncing bet																	
Stellaria aquatica Water chickweed																	
CERATOPHYLLACEAE																	
Ceratophyllum demersum Coontail																	
CHENOPODIACEAE																	
Cheñopodium album White pigweed	P										P						
Chenopodium gigantospermum Pigweed			P														
Corispermum hyssopifolium Hyssop-leaved pigweed		P															
Cycloloma atriplicifolium Winged pigweed						P											

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Pool:	Upper			Lower	1			2			Minn. River			St. Croix River			
Species / Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
<u>Herbs (Continued)</u>																	
CISTACEAE																	
Helianthemum bicknellii Frostweed																	
COMMELINACEAE																	
Tradescantia bracteata Bracted spiderwort																	
Tradescantia occidentalis Western Spiderwort																	
COMPOSITAE																	
Achillea millefolium Yarrow																	
Ambrosia artemisiifolia Common ragweed	P			P										P			
Ambrosia sp. Ragweed		P						P									
Antennaria plantaginifolia Pussytoes																	
Anthemis cotula Mayweed																	
Arctium minus Burdock																	
Artemisia biennis Biennial wormwood	P										P		P				
Aster novae-angilae New England aster																	P
Aster spp. Aster									D	P		P	P	P			P

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

		SAF															
Pool:	Upper			Lower	1			2			Minn. River			St. Croix River			
Species Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
<u>Herbs (Continued)</u>																	
COMPOSITAE (Continued)																	
Bidens beckii Water marigold																	
Bidens connata Beggar's ticks																	
Bidens sp. Bur marigold	P			P							P		P				
Carduus nutans Musk thistle																	
Cirsium arvense Canada thistle		P			P							P					
Crepis tectorum Hawk's beard																	
Erigeron annuus Daisy fleabane		P		P			P										
Erigeron canadensis Horseweed		P															
Erigeron philadelphicus Fleabane											P						
Erigon pulchellus Robin's plantain																	
Erigeron strigosus White-top																	
Eupatorium maculatum Joe-Pye weed																	
Eupatorium perfoliatum Thoroughwort																	
Eupatorium rugosum White snakeroot	D	P	P	P	P	P	P										

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

		SAF															
	Pool:	Upper			Lower	1			2			Minn. River			St. Croix River		
Species	Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
Herbs (Continued)																		
COMPOSITAE (Continued)																		
Grindelia squarrosa Curlycup-gumweed																		
Helianthus occidentalis Western sunflower																		
Helianthus petiolarus Petioled sunflower						P												
Heliopsis helianthoides Ox-eye			P															
Krigia biflora Dwarf dandelion																		
Lactuca sp, Lettuce			P			P					P	P	P					
Prenanthes alba Rattlesnake root																		
Ratibida pinnata Coneflower																		
Rudbeckia hirta Black-eyed Susan																		
Senecio pauperculus Ragwort																		
Senecio plattensis Ragwort																		
Silphium perfoliatum Cup-plant, Rosinweed																		
Solidago altissima Tall goldenrod						P												
Solidago flexicaulis Zig-zag goldenrod																		

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Species	SAF Upper AA	SAF Upper BB	SAF Upper CC	SAF Lower BB	1 AA	1 BB	1 CC	2 AA	2 BB	2 CC	Minn. River AA	Minn. River BB	Minn. River CC	St. Croix River AA	St. Croix River BB	St. Croix River YY	St. Croix River CC
Herbs (Continued)																	
COMPOSITAE (Continued)																	
Solidago gigantea Giant goldenrod		P															
Solidago graminifolia Grass-leaved goldenrod																	
Solidago nemoralis Gray goldenrod																	
Solidago so. Goldenrod	P			P	P			P	P	P			P	P	P	P	P
Taraxacum officinale Dandelion		P		P		P					P		P			P	P
Vernenia fasciculata Western ironweed								P									
Xanthium italicum Common cocklebur	P	P		P		P	P	P			P						
CRUCIFERAE																	
Berteroa incana Hoary alyssum																	
Brassica nigra Black mustard																	
Cardamine pensylvanica Bitter cress																	
Hesperis matronalis Dames violet																	
Lepilium virginicum Poor-man's pepper	P																
Nasturtium officinale Watercress														P			

Table 1 . Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Pool:	SAF Upper			SAF Lower	1			2			Minn. River			St. Croix River			
Species / Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
Herbs (Continued)																	
CRUCIFERAE (Continued)																	
Rorippa islandica Icelandic yellow cress																	
Rorippa obtusa Obtuse yellow cress																	
Unidentified sp.	P																
CUCURBITACEAE																	
Sicyos angulatus Bur-cucumber					P												
CYPERACEAE																	
Carex aenea Sedge																	
Carex annectens Sedge																	
Carex cephalophora Oval-headed sedge																	
Carex communis Sedge																	
Carex stenophylla Involute-leaved sedge																	
Carex laxiflora Sedge																	
Carex lurida Sedge																	
Carex meadii Sedge																	

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Species	SAF Upper AA	SAF Upper BB	SAF Upper CC	SAF Lower BB	Pool 1 AA	Pool 1 BB	Pool 1 CC	Pool 2 AA	Pool 2 BB	Pool 2 CC	Minn. River AA	Minn. River BB	Minn. River CC	St. Croix River AA	St. Croix River BB	St. Croix River YY	St. Croix River CC
Herbs (Continued)																	
CYPERACEAE																	
Carex normalis Sedge																	
Carex sartwellii Sartwell's sedge																	
Carex stipata Awl-fruited sedge																	
Carex umbellata Sedge																	
Carex vulpinoidea Fox sedge																	
Cyperus filiculmis Galingale																	
Cyperus inflexus (or aristotus) Awned cyperus								P			P						
Cyperus orbiculari Galingale								P									
Cyperus schweinitzii Galingale																	
Cyperus sp. Galingale											P						
Eleocharis palustris Spike-rush																	
Hemicarpha micrantha Least hemicarpha								P									
Scirpus americanus Sword grass																	

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Pool:	SAF Upper			SAF Lower	1			2			Minn. River			St. Croix River			
Species / Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
<u>Herbs (Continued)</u>																	
CYPERACEAE																	
Scirpus atrovirens Georgian bulrush																	
Scirpus cyperinus Woolgrass																	
Scirpus rubrotinctus Bulrush																	
Scirpus validus Giant bulrush																	
Unidentified sp.													P	P		P	
DIOSCOREACEAE																	
Dioscorea villosa Wild yam																	
EQUISETACEAE																	
Equisetum arvense Field horsetail							P			D	P	P	P	P			
Equisetum hyemale Scouring rush																	
Equisetum pratense Meadow horsetail																	
EUPHORBIACEAE																	
Euphorbia corollata Flowering spurge																	
Euphorbia cyparissias Cypress spurge																	

Table 1 . Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Pool:	SAF Upper			SAF Lower	1			2			Minn. River			St. Croix River			
Species / Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
<u>Herbs (Continued)</u>																	
EUPHORBIACEAE (Continued)																	
Euphorbia esula Leafy spurge		P		P							P						
Euphorbia sp. Spurge			P					P									
Euphorbia glyptosperma Engraved-seed spurge																	
Euphorbia nutans Eyebane																	
FABACEAE (LEGUMINOSAE)																	
Amorpha canescens Prairie lead-plant																	
Astragalus crassicarpus Ground plum																	
Medicago lupulina Black medick			P		P												
Melilotus alba White sweet clover	P	M			P	D	P					P				P	
Petalostemum candidum White prairie clover																	
Vicia cracca Tufted vetch																	
Vicia villosa Hairy vetch																	
GERANIACEAE																	
Geranium spp. Wild geranium				P													

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Pool:	SAF Upper			SAF Lower	1			2			Minn. River			St. Croix River			
Species / Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
Herbs (Continued)																	
GUTTIFERAE																	
Hypericum sp. St. John's-wort																	P
GRAMINEAE																	
Agrostis palustris Creeping bentgrass										P							
Bouteloua curtipendula Side-oats grama																	
Calamagrostis canadensis Reed bentgrass	P																
Echinochloa sp.	D				P	P		p			p						
Elymus canadensis Canadian wild rye						P				P							
Elymus virginicus Virginian wild rye	P																
Eragrostis hirsuta Hairy love-grass	P										P		D				
Eragrostis hypnoides Creeping love-grass	D																
Eragrostis pectinacea Pursh's love-grass	D							P			M	P					
Glyceria grandis Reed meadow-grass																	
Glyceria striata Fowl meadow-grass																	
Panicum capillare Witch grass	M							P			P	P			P		
Panicum depauperatum Panic grass																	

Table. 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Pool:	SAF Upper			SAF Lower	1			2			Minn. River			St. Croix River			
Species: Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
<u>Herbs (Continued)</u>																	
GRAMINEAE (Continued)																	
Panicum dichotomiflorum Spreading witch grass	P																
Panicum virgatum Switch grass											P						
Phalaris arundinacea Canary grass																	
Poa palustris Fowl meadow-grass		P															
Poa pratensis Blue grass																	
Setaria viridis Green foxtail		P				P		P				P				D	
Setaria sp. Bristly foxtail													P				
Spartina pectinata Prairie cord grass								P									
Unidentified sp.	D				P		P										
HYDROCHARITACEAE																	
Vallisneria spiralis Wild celery																	
HYDROPHYLLACEAE																	
Ellisia nyctelea (No common name)																	
Hydrophyllum appendiculatum Virginia waterleaf																	

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Pool:	SAF Upper			SAF Lower	1			2			Minn. River			St. Croix River			
Species — Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
<u>Herbs (Continued)</u>																	
HYPERICACEAE																	
Hypericum perforatum St. John's-wort																	
Hypericum punctatum Spotted St. John's-wort																	
IRIDACEAE																	
Sisyrinchium campestre Blue-eyed grass																	
JUNCACEAE																	
Juncus balticus Spikerush																	
Juncus compressus Spikerush																	
Juncus effusus Spikerush																	
Juncus longistylis Spikerush																	
Juncus secundus Spikerush																	
LABIATAE																	
Galeopsus tetrahit Hemp-nettle																	
Glecoma hederacea Creeping Charlie																	
Hedeoma hispida Mock pennyroyal																	

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Pool:	SAF Upper			SAF Lower	1			2			Minn. River			St. Croix River			
Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
<u>Herbs (Continued)</u>																	
LABIATAE (Continued)																	
Leonurus cardiaca Motherwort						P					P						
Lycopus officinalis Water horehound																	
Lycopus virginicus Bugleweed																	
Monarda fistulosa Wild bergamot, horsemint																	
Mentha arvensis American wild mint			P					P									
Nepeta cataria Catnip					P												
Physostegia virginiana Obedient plant																	
Prunella vulgaris Mad-dog skullcap																	
Scutellaria lateriflora Leonard's skullcap																	
Stachys palustris Hedge-nettle			P														
Teucrium canadense American germander																	
Unidentified sp.			P					P	P							P	
LEMNACEAE																	
Lemna spp. Duckweed																	

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

	SAF				1			2			Minn. River			St. Croix River			
Pool:	Upper			Lower													
Species / **Transect:**	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
<u>Herbs (Continued)</u>																	
LILIACEAE																	
Allium cernuum Wild onion																	
Lilium superbum Turk's-cap lily																	
Maianthemum canadense Wild lily-of-the-valley																	
Smilacina spp. False Solomon's seal																P	
Smilax sp. Greenbrier																P	
Trillium spp. Trillium																	
LOBELIACEAE																	
Lobelia spicata Highbelia, pale-spike lobelia																	
MENISPERMACEAE																	
Menispermum canadense Yellow parilla						P											
NAJADACEAE																	
Najas sp. Naiad																	
Zannichellia palustris Horned pondweed																	

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Pool:	SAF Upper			SAF Lower	1			2			Minn. River			St. Croix River			
Species / Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
Herbs (Continued)																	
NYCTAGINACEAE																	
Mirabilis hirsuta Hairy umbrellawort		P															
ONAGRACEAE																	
Circaea quadrisulcata Tall enchanter's nightshade																	
Epilobium ciliatum Willow herb																	
Epilobium paniculatum Willow herb																	
Oenothera biennis Evening primrose		P															
OPHIOGLOSSACEAE																	
Botrychium virginianum Rattlesnake fern																	
OSMUNDACEAE																	
Osmunda claytoniana Cinammon fern															P		
OXALIDACEAE																	
Oxalis dillenii Wood sorrel											P						
Oxalis stricta Upright wood sorrel																	
Oxalis violacea Violet wood sorrel																	

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Species	SAF Upper AA	SAF Upper BB	SAF Upper CC	SAF Lower BB	Pool 1 AA	Pool 1 BB	Pool 1 CC	Pool 2 AA	Pool 2 BB	Pool 2 CC	Minn. River AA	Minn. River BB	Minn. River CC	St. Croix River AA	St. Croix River BB	St. Croix River YY	St. Croix River CC
<u>Herbs (Continued)</u>																	
PAPAVERACEAE																	
Sanguinaria canadensis Bloodroot																	
PHYRMACEAE																	
Phyrma leptostachya Lopseed																	
PLANTAGINACEAE																	
Plantago major Common plantain	M									P		P	P				
Plantago rugelii Wood plantain																	
POLEMONIACEAE																	
Phlox divaricata Blue phlox																	
Phlox pilosa Phlox																	
Polemonium reptans Jacob's ladder																	
POLYGONACEAE																	
Polygonum ariculare Common knotweed																	
Polygonum coccineum Scarlet smartweed																	
Polygonum pensylvanicum Pennsylvania smartweed					P			P									
Polygonum sp. Smartweed	P										P	P	P				

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

	SAF																
Pool:	Upper			Lower	1			2			Minn. River			St. Croix River			
Species Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
Herbs (Continued)																	
POLYGONACEAE (Cont'd.)																	
Rumex acetosella Sheep sorrel																	
Rumex crispus Curled dock		P											P				
Rumex mexicanus Mexican dock	P																
Rumex sp. Dock		P			P						P			P		P	
POLYPODIACEAE																	
Adiantum pedatum Maidenhair fern																	
Cystoperis fragilis Fragile bladder-fern														P	P	P	
PRIMULACEAE																	
Lysimachia nummularia Moneywort																	
Lysimachia ciliata Loosestrife																	
RANUNCULACEAE																	
Anemone canadensis Canadian amenome																	
Anemone caroliniana Carolina anemone																	
Anemone cylindrica Thimbleweed																	
Anemone quinquefolia Wood anemone																	

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Pool:	SAF Upper			SAF Lower	1			2			Minn. River			St. Croix River			
Species / Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
Herbs (Continued)																	
RANUNCULACEAE																	
Anemone virginiana Thimbleweed																	
Anemone sp. Anemone														P	P	P	P
Anemonella thalictroides Rue anemone																	
Aquilegia canadensis Columbine													P	P			
Delphinium virescens Larkspur																	
Hepatica acutiloba Liverleaf, hepatica										P							
Hepatica americana Liverleaf, hepatica																	
Ranunculus acris Tall buttercup																	
Ranunculus abortivus Kidneyleaf buttercup																	
Ranunculus aquatilis White water-crowfoot																	
Ranunculus pensylvanicus Bristly crowfoot																	
Ranunculus rhomboideus Prairie buttercup																	
Ranunculus sceleratus Cursed crowfoot											P						
Ranunculus septentrionalis Swamp buttercup																	

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Pool:	SAF Upper			SAF Lower	1			2			Minn. River			St. Croix River			
Species / Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
Herbs (Continued)																	
ROSACEAE																	
Potentilla recta Upright cinquefoil																	
Potentilla simplex Old-field cinquefoil																	
Potentilla sp. Cinquefoil											P		P				
Rosa blanda Smooth wild rose										P							
Rosa suffulta Hairy prairie rose																	
Rosa sp. Rose													P		P		
Rubus occidentalis Black raspberry																	
RUBIACEAE																	
Galium boreale Northern bedstraw																	
Galium trifidum Small bedstraw																	
Houstonia longifolia Bluet																	
SANTALACEAE																	
Comandra umbellata Bastard toadflax																	

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

	SAF																
Pool:	Upper			Lower	1			2			Minn. River			St. Croix River			
Species Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
Herbs (Continued)																	
RANUNCULACEAE (Cont'd.)																	
Ranunculus sp. Buttercup											P						
Thalictrum dasycarpum Purple meadow-rue																	
Thalictrum sp. Meadow-rue										P				P			
RHAMNACEAE																	
Ceanothus americanus New Jersey tea																	
ROSACEAE																	
Agrimonia pubescens Cocklebur																	
Alchemilla sp. Lady's mantle													P				
Fragaria vesca Wild strawberry																	
Geum canadense White avens																	
Geum laciniatum Avens																	
Geum triflorum Three-flowered avens																	
Potentilla argentea Silvery cinquefoil																	
Potentilla arguta Tall cinquefoil																	
Potentilla norvegica Rough cinquefoil											A						

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

	SAF																
Pool:	Upper			Lower	1			2			Minn. River			St. Croix River			
Species / Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
<u>Herbs (Continued)</u>																	
SAXIFRAGACEAE																	
Heuchera americana Alumroot																	
Heuchera richardsonii Richardson's alumroot																	
Ribes sp. Currant											P					P	
SCROPHULARIACEAE																	
Besseya bullii (No common name)																	
Linaria vulgaris Butter-and-eggs					P												
Mimulus glabratus Monkey-flower																	
Mimulus ringens Square-stemmed monkey-flower											P						
Penstemon gracilis Slender-leaved beard-tongue																	
Penstemon grandiflorus Large-flowered beard-tongue																	
Scrophularia lanceolata Figwort																	
Verbascum thapsus Mullein																	
Veronica americana Speedwell																	
Veronicastrum virginicum Culver's root																	
Unidentified sp.	P																

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Pool:	SAF Upper			SAF Lower	1			2			Minn. River			St. Croix River			
Species / Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
<u>Herbs (Continued)</u>																	
SOLANACEAE																	
Physalis heterophylla Clammy ground-cherry																	
Physalis longifolia Ground-cherry																	
Solanum nigrum var. *americana* Black nightshade			P	P					P		P						
SPARGANIACEAE																	
Sparganium Bur-reed																	
TYPHACEAE																	
Typha latifolia Cattail														P			
UMBELLIFERAE																	
Angelica atropurpurea Alexander																	
Cryptotaenia canadensis Wild chervil																	
Heracleum lanatum Cow parsnip																	
Osmorhiza longistylis Sweet cicely																	
Pastinaca sativa Wild parsnip																	
Sanicula marilandica Black snakeroot																	
Zizea aurea Golden alexander																	

AD-A110 142 NORTH STAR RESEARCH INST MINNEAPOLIS MN ENVIRONMENTAL--ETC F/G 13/2
ENVIRONMENTAL IMPACT STUDY OF THE NORTHERN SECTION OF THE UPPER--ETC(U)
NOV 73 R F COLINGSWORTH, B J GUDMUNDSON DACW37-73-C-0059

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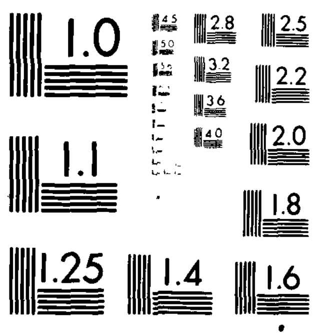
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Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

	SAF																
Pool:	Upper			Lower	1			2			Minn. River			St. Croix River			
Species Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
<u>Herbs (Continued)</u>																	
URTICACEAE																	
Boehmeria cylindrica False nettle																	
Parietaria pensylvanica Pennsylvania pelli-tory	P	D															
Urtica dioica Stinging nettle											P						
Laportia canadensis Canadian wood-nettle										P							
Unidentified sp.		P							P				P	P			
VERBENACEAE																	
Verbena bracterata Large-bracted vervian	P																
Verbena hastata Blue vervain																	
Verbena simplex Vervain																	
Verbena stricta Hoary vervain																	
Verbena urticifolia White vervain																	
VIOLACEAE																	
Viola pedata Bird's-foot violet																	
VITACEAE																	
Parthenocissus inserta Thicket creeper, woodbine																	

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

	SAF																
Pool:	Upper			Lower	1			2			Minn. River			St. Croix River			
Species Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
<u>Herbs (Continued)</u>																	
HEPATICAE (Liverworts)														P			
MUSCI (mosses)														P	P	P	P

Table 2 . Partial List of Plants of the Lower St. Croix River Valley (Taylors Falls to Prescott) (BOR, 1972)

(common names in parenthesis)

ACERACEAE

<u>Acer negundo</u> (Box Elder)
<u>Acer nigrum</u> (Black Maple)
<u>Acer rubrum</u> (Red Maple)
<u>Acer saccharinum</u> (Silver Maple or Soft Maple)
<u>Acer saccharum</u> (Sugar Maple)
<u>Acer spicatum</u> (Mountain Maple)

AIZOACEAE

<u>Mollugo verticillata</u> (Carpetweed)

ALISMACEAE

<u>Sagittaria</u> sp. (Arrowhead)

ANACARDIACEAE

<u>Rhus glabra</u> (Smooth Sumac)
<u>Rhus radicans</u> (Poison Ivy)

APOCYNACEAE

<u>Apocynum androsaemifolium</u> (Dogbane)

ARACEAE

<u>Arisaema triphyllum</u> (Jack-in-the-Pulpit)
<u>Symplocarpus</u> <u>foetida</u> (Skunk Cabbage)

ARALIACEAE

<u>Aralia nudicaulis</u> (Wild Sarsaparilla)
<u>Panax quinquefolius</u> (Ginseng)
<u>Panax trifolius</u> (Dwarf Ginseng)

ASCLEPIADACEAE

<u>Asclepias exaltata</u> (Tall Milkweed)
<u>Asclepias ovalifolia</u> (Oval-leafed Milkweed)
<u>Asclepias syriaca</u> (Common Milkweed)
<u>Asclepias tuberosa</u> (Butterflyweed)
<u>Asclepias verticillata</u> (Whorled-leafed Milkweed)

Table 2. Partial List of Plants (Continued)

BETULACEAE

<u>Alnus incana</u> (Speckled Alder)
<u>Betula papyrifera</u> (Paper Birch)
<u>Carpinus caroliniana</u> (Blue Beech or American Hornbeam)
<u>Ostrya virginiana</u> (Ironwood or Hop Hornbeam)

BORAGINACEAE

<u>Hackelia virginiana</u> (Beggar's Lice)
<u>Lappularedowskii</u> (Stickseed)
<u>Lithospermum canescens</u> (Hoary Puccoon)
<u>Lithospermum carolinense</u> (Hairy Puccoon)
<u>Lithospermum incisum</u> (Narrow-Leaved Puccoon)
<u>Onosmodium molle</u> (Marble-seed, False Gromwell)

CAMPANULACEAE

<u>Campanula rotundifolia</u> (Harebell)

CAPRIFOLIACEAE

<u>Diervilla lonicera</u> (Bush-Honeysuckle)
<u>Lonicera prolifera</u> (Grape Honeysuckle)
<u>Lonicera tatarica</u> (Tartarian Honeysuckle)
<u>Sambucus canadensis</u> (Common Elder)
<u>Sambucus pubens</u> (Red-berried Elder)
<u>Symphoricarpos occidentalis</u> (Wolfberry)
<u>Symphoricarpos orbiculatus</u> (Coralberry)
<u>Triostium perfoliatum</u> (Horse-Gentian, Feverwort, Wild Coffee)
<u>Virburnum cassinoides</u> (Wild Raisin)

CARYOPHYLLACEAE

<u>Cerastium arvense</u> (Field Chickweed)
<u>Cerastium nutans</u> (Nodding Chickweed)
<u>Cerastium vulgatum</u> (Common Mouse-Eared Chickweed)
<u>Saponaria officinalis</u> (Soapwort, Bouncing Bet)
<u>Stellaria aquatica</u> (Water Chickweed)

CERATOPHYLLACEAE

<u>Ceratophyllum demersum</u> (Coontail or Hornwort)

CISTACEAE

<u>Helianthemum bicknellii</u> (Hoary Frostweed)

COMMELINACEAE

<u>Tradescantia bracteata</u> (Long-Bracted Spiderwort)
<u>Tradescantia occidentalis</u> (Western Spiderwort)

Table 2. Partial List of Plants (Continued)

COMPOSITAE

Achillea millefolium (Common Yarrow)
Arctium minus (Common Burdock)
Antennaria plantaginifolia (Pussytoes or Plantain-Leaved Everlasting)
Anthemis cotula (Mayweed, Fetid Chamonile)
Aster novae-angilae (New England Aster)
Aster spp. (Aster)
Bidens beckii (Water Marigold, Beggar's Ticks)
Bidens connata (Purple-Stemmed Beggar's Ticks)
Carduus nutans (Musk-Thistle)
Cirsium arvense (Canada Thistle)
Conyza canadensis (Horseweed)
Crepis tectorum (Hawk's-Beard)
Erigeron annuus (Daisy Fleabane)
Erigeron Philadelphicus (Philadelphia Fleabane)
Erigeron pulchellus (Robin's Plantain)
Erigeron strigosus (White Top or Slender Daisy Fleabane)
Eupatorium maculatum (Joe-Pye Weed)
Eupatorium perfoliatum (Thoroughwort, Common Boneset)
Helianthus occidentalis (Sunflower)
Krigia biflora (Dwarf Dandelion)
Prenanthes alba (Rattlesnake-root)
Ratibida pinnata (Gray-Headed Coneflower)
Rudbeckia hirta (Black-Eyed Susan)
Senecio pauperculus (Dwarf Groundsel)
Senecio plattensis (Ragwort, Prairie Ragwort)
Silphium perfoliatum (Cup-Plant, Rosin-Weed)
Solidago flexicaulis (Zig-Zag Goldenrod)
Solidago gigantea (Giant Goldenrod, Lake Goldenrod)
Solidago graminifolia (Grass-Leaved Goldenrod, Bushy A.)
Solidago nemoralis (Eastern Gray Goldenrod)

CONVALLARIACEAE

Vagnera Spp. (Solomon's Seal)

CORNACEAE

Cornus alternifolia (Green Osier, Alternate-Leaved Dogwood, Pagoda Tree)
Cornus racemosa (Panicled Dogwood)

CRUCIFERAE

Berteroa incana (Hoary Alyssum)
Cardamine pennsylvanica (Pennsylvania Bitter Cress)
Hesperis matronalis (Dame's Violet)
Nasturtium officinale (Watercress)
Rorippa obtusa (Yellow Cress)

Table 2. Partial List of Plants (Continued)

CUPRESSACEAE

Juniperus virginiana (Red Cedar)
Thuja occidentalis (White Cedar)

CYPERACEAE

Carex aenea (Sedge)
Carex annectens (Sedge)
Carex cephalophora (Oval-Headed Sedge)
Carex communis (Sedge)
Carex eleocharis (Involute-Leaved Sedge)
Carex laxiflora (Sedge)
Carex lurida (Sedge)
Carex meadii (Sedge)
Carex normalis (Sedge)
Carex sartwellii (Sartwell's Sedge)
Carex stipata (Awe-Fruited Sedge)
Carex umbellata (Sedge)
Carex vulpinoidea (Fox Sedge)
Cyperus filiculmis (Slender Cyperus, Galingale)
Cyperus schweinitzii (Schweinitz's Cyperus, Galingale)
Eleocharis palustris (Spike Rush)
Scirpus americanus (Sword Grass, Three-Square Grass)
Scirpus atrovirens (Bulrush)
Scirpus cyperinus (Wool Grass)
Scirpus rubrotinctus (Bulrush)
Scirpus validus (Giant Bulrush)

DIOSCOREACEAE

Dioscorea villosa (Wild Yam)

EQUISETACEAE

Equisetum hyemale (Tall Scouring-Rush)
Equisetum pratense (Meadow Horsetail)

EUPHORBIACEAE

Euphorbia corollata (Flowering Spurge)
Euphorbia cyparissias (Cypress Spurge)
Euphorbia glyptosperma (Ridge-Seeded Spurge)
Euphorbia nutans (Eyebane)

FABACEAE or LEGUMINOSAE

Amorpha canescens (Prairie Lead Plant)
Astragalus crassicarpus (Ground Plum)
Melilotus alba (White Sweet Clover)
Petalostemum candidum (White Prairie Clover)
Petalostemum purpureum (Purple Prairie Clover)
Vicia cracea (Tufted Vetch)
Vicia villosa (Hairy Vetch)

Table 2. Partial List of Plants (Continued)

FAGACEAE

Quercus alba (White Oak)
Quercus macrocarpa (Bur Oak or Mossycup Oak)
Quercus rubra (Red Oak)
Quercus velutina (Black Oak)

GERANIACEAE

Geranium spp. (Wild Geranium)

GRAMINEAE

Agrostis palustris (Creeping Bentgrass)
Bouteloua curtipendula (Side-Oats Grama)
Eragrostis pectinaceae (Pursh's Love Grass)
Glyceria grandis (Reed Meadow Grass)
Glyceria striata (Fowl Meadow Grass or Nerved Meadow Grass)
Panicum depauperatum (Panic Grass)
Phalaris arundinacea (Reed Canary Grass)
Poa pratensis (Kentucky Blue Grass)

HYDROPHYLLACEAE

Ellisia nyctelea (Ellisia)
Hydrophyllum appendiculatum (Appendaged Waterleaf)

HYPERICACEAE

Hypericum perforatum (Perforated St. John's Wort)
Hypericum punctatum (Spotted St. John's Wort)

IRIDACEAE

Sisyrinchium campestre (Prairie Blue-Eyed Grass)

JUNCACEAE

Juncus balticus (Spikerush)
Juncus compressus (Spikerush)
Juncus effusus (Spikerush)
Juncus longistylis (Spikerush)
Juncus secundus (Spikerush)

LABIATAE

Galeopsus tetrahit (Hemp-Nettle)
Glecoma hederacea (Creeping Charlie)
Hedeoma hispida (Mock Pennyroyal)
Leonurus cardiaca (Motherwort)
Lycopus officinalis (Water Horehound)
Lycopus virginicus (Bugleweed)

Table 2. Partial List of Plants (Continued)

Monarda fistulosa (Wild Bergamot, Horsemint)
Nepeta cataria (Catnip)
Prunella vulgaris (Selfheal)
Scutellaria lateriflora (Mad-Dog Skullcap)
Scutellaria parvula (Skullcap)
Teucrium canadense (American Germander)

LEMNACEAE

Lemna spp. (Duckweed)

LILIACEAE

Allium cernuum (Nodding Wild Onion)
Lilium superbum (Turk's-Cap Lily)
Maianthemum canadense (Wild Lilly-of-the-Valley)
Trillium spp. (Trillium)

LOBELIACEAE

Lobelia spicata (Highbelia, Pale-Spile Lobelia)

NAJADACEAE

Najas sp. (Naiad)
Zannichellia palustris (Horned Pondweed)

NYCTAGINACEAE

Oxybaphus hirsutus (Hairy Umbrellawort)

OLEACEAE

Fraxinus nigra (Black Ash)
Fraxinus pensylvanica, var. subintegerrima (Green Ash)

ONAGRACEAE

Circaea quadrisulcata (Tall Enchanter's Nightshade)
Epilobium ciliatum (Willow Herb)
Epilobium paniculatum (Willow Herb)
Oenothera biennis (Common Evening Primrose)

OPHIOGLOSSACEAE

Botrychium virginianum (Rattlesnake Fern or Virginia Grape Fern)

OXALIDACEAE

Oxalis stricta (Upright Wood-Sorrel)
Oxalis violacea (Violet Wood-Sorrel)

Table 2. Partial List of Plants (Continued)

PAPAVERACEAE

Sanguinaria canadensis (Bloodroot)

PHYRMACEAE

Phyrma leptostachya (Lopseed)

PINACEAE

Larix laricina (Tamarack)
Picea canadensis (White Spruce)
Pinus resinosa (Red Pine)
Pinus strobus (White Pine)

PLANTACINACEAE

Plantago major (Common Plantain)
Plantago Rugelii (Wood Plantain or Rugel's Plantain)

POLEMONIACEAE

Phlox divaricata (Phlox)
Phlox pilosa (Prairie Phlox)
Polemonium reptans (Jacob's Ladder)

POLYGONACEAE

Polygonum coccineum (Scarlet Smartweed or Swamp Smartweed)
Rumex acetosella (Sheep-Sorrel)
Rumex crispus (Yellow-Dock or Curled-Dock)

POLYPODIACEAE

Adiantum pedatum (Maiden Hair Fern)
Cystopteris fragilis (Bladder Fern)

PRIMULACEAE

Lysimachia nummularia (Moneywort)
Lysimachia ciliata (Fringed Loosestrife)

RANUNCULACEAE

Anemone canadensis (Canadian Anemone)
Anemone caroliniana (Carolina Anemone)
Anemone cylindrica (Thimble Weed)
Anemone quinquefolia (Wood Anemone)
Anemone virginiana (Tall Thimble Weed)
Anemonella thalictroides (Rue Anemone)
Aquilegia canadensis (Wild Columbine)
Delphinium virescens (Prairie Larkspur)

Table 2. Partial List of Plants (Continued)

Hepatica acutiloba (Hepatica, Sharp-Leaved Liverleaf)
Hepatica americana (American Liverleaf, Hepatica)
Ranunculus acris (Tall Buttercup)
Ranunculus abortivus (Kidneyleaf)
Ranunculus aquatilis (White Water-Crowfoot)
Ranunculus pensylvanicus (Bristly Crowfoot or Buttercup)
Ranunculus rhomboideus (Prairie Buttercup or Crowfoot)
Rannunculus septentrionalis (Swamp Buttercup)
Thalictrum dasycarpum (Purple Meadow-Rue or Tall Meadow-Rue)

RHAMNACEAE

Ceanothus americanus (New Jersey Tea)

ROSACEAE

Agrimonia pubescens (Cocklebur)
Amelanchier huronensia (Service berry, Shadbush)
Amelanchier spp. (Juneberry)
Crataegus spp. (Thorn-Apple)
Fragaria vesca (Wild Strawberry)
Geum canadense (White Avens)
Geum laciniatum (Avens)
Geum triflorum (Three-flowered Avens)
Physocarpus opulifolius (Ninebark)
Potentilla argentea (Silvery Cinquefoil)
Potentilla argua (Tall Cinquefoil)
Potentilla norvegica (Cinquefoil)
Potentilla recta (Upright Cinquefoil, Rough-Fruited Cinquefoil)
Potentilla simplex (Old-Field Cinquefoil)
Prunus americana (American Wild Plum)
Prunus pensylvanica (Pin Cherry)
Prunus Virginiana (Choke cherry)
Rosa blanda (Smooth Wild Rose)
Rosa suffulta (Wild Rose)
Rubus occidentalis (Black Raspberry)

RUBIACEAE

Galium boreale (Northern Bedstraw)
Galium trifidum (Small Bedstraw)
Houstonia longifolia (Bluet)

SALICACEAE

Populus deltoides (Cottonwood)
Populus grandidentata (Bigtooth Aspen)
Populus tremuloides (Quaking Aspen)
Salix humilis (Small Pussy-Willow)
Salix interior (Sand-bar Willow)
Salix nigra (Black Willow)
Salix spp. (Willows)

Table 2. Partial List of Plants (Continued)

SANTALACEAE

Comandra umbellata (Bastard Toadflax)

SAXIFRAGACEAE

Heuchera hirsuticaulis (Alum Root)
Heuchera Richardsonii (Alum Root)

SCROPHULARIACEAE

Besseya bullii (no common name)
Linaria vulgaris (Butter-and-Eggs)
Mimulus glabratus (Monkey Flower)
Mimulus ringens (Square-Stemmed Monkey Flower)
Penstemon gracilis (Slender-Leaved Beard-Tongue)
Penstemon grandiflorus (Large Flowered Beard-Tongue)
Scrophularia lanceolata (Lance-Leaved Figwort)
Verbascum Thapsus (Great Mullein)
Veronica americana (Speedwell)
Veronicastrum virginicum (Culver's Root)

SOLANCEAE

Physalis heterophylla (Clammy Ground Cherry)
Physalis longifolia (Ground Cherry)

SPARGANACEAE

Sparganium (Bur-Reed)

TILIACEAE

Tilia americana (American Basswood or Linden)

TYPHACEAE

Typha latifolia (Broad-Leaved Cattail)

ULMACEAE

Celtis occidentalis (Hackberry)
Ulmus americana (American Elm)
Ulmus rubra (Slippery Elm)

UMBELLIFERAE

Angelica atropurpurea (Alexander)
Cryptotaenia canadensis (Wild Chervil, Canadian Honewort)
Heracleum lanatum (Cow Parsnip)
Osmorhiza longistylis (Anise-Root, Smooth Sweet Cicely)
Pastinaca sativa (Wild Parsnip)
Sanicula marilandica (Black Snakeroot)
Zizea aurea (Golden Alexander)

Table 2. Partial List of Plants (Continued)

URTICACEAE

Boehmeria cylindrica (False Nettle)
Urtica dioica (Stinging Nettle)

VALLISNERIACEAE

Vallisneria spiralis (Wild Celery)

VERBENACEAE

Verbena bracteata (Vervain)
Verbena hastata (Blue Vervain)
Verbena simplex (Vervain)
Verbena stricta (Hoary Vervain)
Verbena urticifolia (White Vervain)

VIOLACEAE

Viola pedata (Birdsfoot, Pansy Violet)

VITACEAE

Vitis riparia (Winter-Grape, Frost Grape)

Table 3. Vegetation of Floodplain (old dredge spoil) and Bluff Habitats on the Minnesota River (Cooper, 1947).

Trees		
	Acer negundo	Box elder
	Acer saccharinum	Soft (Silver) Maple
	Fraxinus nigra	Black ash
	Fraxinus pennsylvanica	White ash
	Fraxinus sp.	Ash
	Populus deltoides	Cottonwood
	Salix amygdaloides	Peach-leaved willow
	Ulmus americana	American elm
	Ulmus rubra	Slippery elm
Shrubs		
	Cornus stolonifera	Red osier dogwood
	Cornus racemosa	Racemose dogwood
	Salix longifolia	Willow
	Sambucus canadensis	Common elder
	Vitis riparia	River-bank grape
Herbs		
	Acalypha rhombodia	Three-seeded mercury
	Anemone virginiana	Tall anemone
	Aster lateriflorus	Calico aster
	Aster sp.	Aster
	Bidens sp.	Stick-tights
	Boehmeria cylindrica	False nettle
	Boltonia latisquama	Small headed boltonia
	Carex gracilima	Sedges
	Cuscuta sp.	Dodder
	Elymus virginicus	Virginia wild rye
	Eupatorium perfoliatum	Common boneset
	Geum sp.	Avens
	Helenium autumnale	Sneezeweed
	Heuchera richardsonii	Alum root
	Laportia canadensis	Wood nettle
	Lathyrus sp.	Wild pea
	Leersia oryzoides	Rice cut-grass
	Lycopus virginicus	Bugle weed
	Menispermum canadense	Moonseed
	Mentha sp.	Mint
	Physostegia speciosa	False dragon-head
	Plantago major	Common plantain
	Oryzopsis sp.	Mountain-rice
	Stachys aspera	Rough hedge nettle
	Urtica gracilis	Slender wild nettle

Table 4. Vegetation of the Spring Lake area (Data from Leisman, 1959).

HABITAT: Ravines and Bluffs

Trees - common
- American elm *Ulmus americana*
- Slippery elm *Ulmus rubra*
- Basswood *Tilia americana*
- Green ash *Fraxinus pennsylvanica* var. *subintegerrima*
- Box elder *Acer negundo*
- Cottonwood *Populus deltoides*
- Red cedar *Juniperus virginiana*

- present
- Ironwood *Ostrya virginiana*
- Butternut *Juglans cinerea*
- Oaks (several) *Quercus* spp.
- Paper birch *Betula papyrifera*

Shrubs - common
- Red-berried elder *Sambucus pubens*
- Missouri gooseberry *Ribes missouriense*
- Prickly gooseberry *Ribes cynosbati*
- Black raspberry *Rubus occidentalis*
- Prickly ash *Xanthoxylum americanum*
- Hazel *Corylus americana*

- present
- Wolfberry *Symphoricarpos occidentalis*

Herbs
- Yellow jewelweed *Impatiens pallida*
- Nettle *Urtica procera*
- Sweet cicely *Osmorhiza* sp.

HABITAT: River Terraces and Uplands

Trees
- Northern red oak *Quercus borealis*
- Pin oak *Q. palustris*
- Bur oak *Q. macrocarpa*
- American elm *Ulmus americana*
- Bitternut hickory *Carya cordiformis*
- Butternut *Juglans cinerea*
- Hackberry *Celtis occidentalis*

Shrubs
- None

Herbs
- Kentucky bluegrass *Poa pratensis*

Table 5. Checklist of Mammals Observed in the lower Kinnickinnic River Valley

Species

Short-tailed Shrew *Blarina brevicauda*
Little Brown Bat *Myotis lucifugus*
Raccoon *Procyon lotor*
Mink *Mustela vison*
Striped Skunk *Mephitis mephitis*
Badger *Taxidea taxys*
Red Fox *Vulpes fulva*
Woodchuck *Marmota monax*
Thirteen-lined Ground Squirrel *Citellus tridecemlineatus*
Eastern Chipmunk *Tamias striatus*
Gray Squirrel *Scirius niger*
Red Squirrel *Tamiasciurus hudsonicus*
Fox Squirrel *Sciurus carolininsis*
Southern Flying Squirrel *Glaucomys volans*
Plains Pocket Gopher *Geomys bursarius*
Beaver *Castor canadensis*
Prairie White-footed Deer Mouse *Peromyscus leucopus*
Woodland White-footed Deer Mouse *Peromyscus maniculatus*
Pennsylvania Meadow Mouse *Microtus pennsylvanicus*
Prairie Vole *Microtus ochrogaster*
Muskrat *Ondatra zibethica*
Woodland Jumping Mouse *Napaeozapus insignis*
Cottontail Rabbit *Sylvilagus floridanus*
White-tailed Deer *Odocoileus virginianus*

Table 6.

The Birds of the Minneapolis-St. Paul Region

This combined field list and migration chart of birds for the Twin Cities and the surrounding area (see unlined area on map) is designed to fit inside A FIELD GUIDE TO THE BIRDS by R. T. Peterson and to be taken into the field as an aid to those who enjoy birding in this region. The list comprises all of the species authoritatively recorded for this area, plus a few based on sight records only. It is hoped that this list may encourage the accumulation of further accurate data and so broaden our knowledge of birds of this area.

The list includes a total of 285 species. The calendar graph on the left hand page is divided into the twelve months of the year; each month is divided into three sections indicating ten days each. In this way approximate dates are indicated. The graph itself is easy to read and should answer the question, "When is the bird found here?"

A solid line indicates a bird present, common to abundant. During summer months this indicates nesting.

Short, closely spaced dashes indicate the bird is here in limited numbers.

Long, widely spaced, dashes indicate the bird is here irregularly, or rarely. Dashed lines during summer months may or may not indicate nesting.

A separate dot indicates a specific record for the bird.

The habitat key following the name of each species should answer the question, "Where is the bird found?"

A. Aquatic

1. Open lakes and rivers
2. Marshes
3. Cattails and marsh borders

Asterisk (*) indicates additional species. See page 28.

B. Shrubs

1. Wet willow growth
2. Brushy hillsides
3. Woods borders
4. Forest undergrowth
5. Brushy creek banks

C. Forests

1. Bottomland
2. Maple-basswood
3. Oak-elm upland
4. Dry oak savannah
5. Conifer

D. Grassland

1. Wet sedge meadows
2. Grassy meadows
3. Dry uplands

E. Urban

F. Aerial

G. Cliffs and banks

H. Sandy beaches

I. Mud flats

The right hand page has been left for the observer to use in recording field trip observations.

The records on which the migration charts are based have been compiled from the files of the Museum of Natural History at the University of Minnesota, THE FLICKER, and THE BIRDS OF MINNESOTA, by Dr. T. S. Roberts. Special thanks are due to Mr. and Mrs. E. D. Swedenborg for the use of their personal records. The compilers want to thank Mrs. Helen Chapman of the Museum staff and Mrs. Margaret Ring of the Continental Machines Company of Savage for help in the mechanics of assembling this pamphlet.

Anne Winton Dodge
Helen Ford Fullerton
Walter J. Breckenridge
Dwain W. Warner

Table 6 (Continued).

Species	Habitat	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Loon	A1												
Red-throated Loon	A1												
Holboell's Grebe	A												
Horned Grebe	A1-2												
Eared Grebe	A1-2												
Pied-billed Grebe	A2-3												
White Pelican	A1												
Double-cr. Cormorant	A1												
Great Blue Heron	A2-3												
American Egret	A2-3												
Green Heron	A3, B-5												
Bl.-cr. Night Heron	A2-3, C-1												
American Bittern	A2-3												
Least Bittern	A3												
Whistling Swan	A1												
Canada Goose	A1-2												
White-fronted Goose	A1-2												
Snow-Blue Goose	A1-2												
Mallard	A												
Black Duck	A												
Gadwall	A												
Baldpate	A												
American Pintail	A												
Green-winged Teal	A												
Blue-winged Teal	A2-3												
Cinnamon Teal	A2-3												
Shoveler	A2-3												
Wood Duck													
Red head	A												
Ring-necked Duck	A												
Canvas-back	A												
Lesser Scaup Duck	A												
Greater Scaup Duck	A												
Golden-eye	A1												
Barrow's Golden eye	A1												
Buffle-head	A1												
Old Squaw	A1												
White-winged Scoter	A1												
Surf Scoter	A1												
American Scoter	A1												
Ruddy Duck	A2-3												
Hooded Merganser	A												
American Merganser	A												
Red-breasted Merganser	A												
Turkey Vulture	F												
Swallow-tailed Kite	F												
Goshawk	C												
Sharp-shinned Hawk	C												

Table 6 (Continued).

Species	Habitat	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Cooper's Hawk	C												
Red-tailed Hawk	F, C												
Red-shouldered Hawk	F, C												
Broad-winged Hawk	F, C												
Rough-legged Hawk	F, D												
Ferruginous Rough-leg	F, D												
Golden Eagle	F												
Bald Eagle	F												
Marsh Hawk	F, D												
Osprey	F, C												
Gyrfalcon	F, D												
Duck Hawk	F, G												
Pigeon Hawk	F, C												
Sparrow Hawk	F, D												
Ruffed Grouse	C												
Prairie Chicken	D												
Sharp-tailed Grouse	B, D												
European Partridge	D												
Bob-white	B2-3												
Ring-necked Pheasant	D												
Sandhill Crane	A2-D												
King Rail	A2-3												
Virginia Rail	A2-3												
Sora	A2-3												
Yellow Rail	D1-2												
Florida Gallinule	A2-3												
Coot	A												
Piping Plover	H												
Semipalmated Plover	I, H												
Killdeer	A, I, D												
Golden Plover	I, D, H												
Black-bellied Plover	I, D, H												
Ruddy Turnstone	H												
Woodcock	B1												
Wilson's Snipe	I, D-1												
Upland Plover	D2-3												
Spotted Sandpiper	I- H												
Solitary Sandpiper	I												
Western Willet	H-I												
Greater Yellow-legs	H- I												
Lesser Yellow-legs	H- I												
Knot	H												
Pectoral Sandpiper	H-I												
White-rumped Sandpiper	H-I												
Baird's Sandpiper	H-I												
Least Sandpiper	H- I												
Red-backed Sandpiper	H- I												
Dowitcher	H- I												

Table 6 (Continued).

Species	Habitat	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Stilt Sandpiper	H, I												
Semipalmated Sandpiper	H, I												
Buff-breasted Sandpiper	D, H, I												
Marbled Godwit	D, H, I												
Hudsonian Godwit	H, I												
Sanderling	H												
Avocet	H, I												
Wilson's Phalarope	DI- A												
Northern Phalarope	A, I												
Herring Gull	A, F												
Ring-billed Gull	A, F												
Franklin's Gull	A, D, F												
Bonaparte's Gull	A, F												
Forster's Tern	A												
Common Tern	A												
Least Tern	H, F												
Caspian Tern	F, A												
Black Tern	A												
Mourning Dove	D												
Rock Dove	E												
Yellow-billed Cuckoo	C												
Black-billed Cuckoo	C												
Screech Owl	C												
Great Horned Owl	C												
Snowy Owl	D												
Hawk Owl	C												
Barred Owl	C												
Great Gray Owl	C												
Long-eared Owl	C												
Short-eared Owl	D												
Saw-Whet Owl	C												
Whip-poor-will	C												
Night hawk													
Chimney Swift	F												
Ruby-th'd Hummingbird	CE												
Belted Kingfisher	C-1, G												
Flicker	C												
Pileated Woodpecker	C												
Red-bellied Woodpecker	C												
Red-headed Woodpecker	C												
Yellow-bellied Sapsucker	C												
Hairy Woodpecker	C												
Dowry Woodpecker	C												
Artic 3-toed Woodpecker	C												
King bird	B-3, C-4, D												
Western [illegible]	C-1, D												
Crested Flycatcher	C												
Phoebe	C-1, B-3												

Table 6 (Continued).

Species	Hab.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Yellow-bellied Flycatcher	C												
Alder Flycatcher	BC												
Least Flycatcher	C												
Wood Pewee	C												
Olive-sided Flycatcher	C												
Horned Lark	D												
Tree Swallow	FB												
Bank Swallow	FG												
Rough-winged Swallow	FG												
Barn Swallow	EF												
Cliff Swallow	GE												
Purple Martin	EF												
Canada Jay	C												
Blue Jay	C												
Magpie	CB												
Raven	CF												
Crow	CF												
Black-capped Chickadee	C												
Hudsonian Chickadee	CS												
Tufted Titmouse	C												
White-breasted Nuthatch	C												
Red-breasted Nuthatch	C												
Brown Creeper	C												
House Wren	EC												
Winter Wren	B-4, C												
Bewick's Wren	C												
Carolina Wren	C												
Long-billed Marsh Wren	A3												
Short-billed Marsh Wren	DI												
Mockingbird	C												
Cat bird	CE												
Brown Thrasher	CE												
Robin	CE												
Wood Thrush	C												
Hermit Thrush	C												
Olive-backed Thrush	C												
Gray-cheeked Thrush	C												
Veery	C												
Bluebird													
Townsend's Solitaire	C												
Blue-gray Gnatcatcher	C												
Golden-crowned Kinglet	C												
Ruby-crowned Kinglet	C												
American Pipit													
Bohemian Waxwing	C												
Cedar Waxwing	C												
Northern Shrike	B-3, C-4, D												
Migrant Shrike	C-4, D												

Table 6 (Continued).

Species	Habitat	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Starling	E												
Bell's Vireo	CB												
Yellow-throated Vireo	C												
Blue-headed Vireo	C												
Red-eyed Vireo	C												
Philadelphia Vireo	C												
Warbling Vireo	C												
Black & White Warbler	C												
Prothonotary Warbler	CI												
Worm-eating Warbler	B4												
Golden-winged Warbler	B3												
Blue-winged Warbler	B2-3												
Tennessee Warbler	C												
Orange-crowned Warbler	C												
Nashville Warbler	C												
Parula Warbler	C												
Yellow Warbler	B2-3, E												
Magnolia Warbler	C												
Cape May Warbler	C												
Black-th'd Blue Warbler	C												
Myrtle Warbler	C												
Audubon's Warbler	C												
Black-th'd Green Warbler	C												
Cerulean Warbler	C												
Blackburnian Warbler	C												
Hooded Warbler	B4												
Chestnut-sided Warbler	B3												
Bay-breasted Warbler	C												
Black-poll Warbler	C												
Pine Warbler	C												
Palm Warbler	CB												
Oven-bird	B4												
Northern Water-Thrush	B5												
Louisiana Water-Thrush	B5												
Connecticut Warbler	B4												
Mourning Warbler	B4												
Yellow-throat	A-3, B1												
Yellow-breasted Chat	B2												
Wilson's Warbler	B3-4, C												
Canada Warbler	C												
Redstart	C												
English Sparrow	E												
Bobolink	D1												
Eastern Meadowlark	D												
Western Meadowlark	D												
Yellow-headed Blackbird	A3												
Red-winged Blackbird	A3												
Orchard Oriole	C3-4												

Table 6 (Continued).

Species	Habitat	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Baltimore Oriole	C												
Rusty Blackbird	C-1												
Brewer's Blackbird	D												
Bronzed Grackle	CDE												
Cowbird	BCDE												
Scarlet Tanager	C												
Cardinal	C												
Rose-breasted Grosbeak	C												
Indigo Bunting	B-2, 3												
Dickcissel	D-2												
Evening Grosbeak	C												
Purple Finch	C												
Pine Grosbeak	C-5												
Hoary Redpoll	D, B-2												
Redpoll	D, B-2												
Pine Siskin	C												
Goldfinch	CB												
Red Crossbill	C-5												
White-winged Crossbill	C-5												
Towhee	C												
Savannah Sparrow	D-2												
Grasshopper Sparrow	D-3												
Leconte's Sparrow	A3, D-1												
Henslow's Sparrow	A3, D-1												
Nelson's Sparrow	A3, D-1												
Vesper Sparrow	D-3												
Lark Sparrow	C-4, D-3												
Slate-colored Junco	C												
Oregon Junco	C												
Tree Sparrow	B, C-1												
Chipping Sparrow	B, C-5, E												
Clay-colored Sparrow	B-2, C-4												
Field Sparrow	B-2, C-4												
Harris's Sparrow	B-3, C												
White-crowned Sparrow	B-3, C												
White-throated Sparrow	C												
Fox Sparrow	C												
Lincoln's Sparrow	B-5, C												
Swamp Sparrow	A-3, B-1												
Song Sparrow	A3, B-1, 5												
Lapland Longspur	D												
Snow Bunting	D												
ADDITIONAL SPECIES													
Western Grebe	A												
Yellow Night Heron	A2-3, C1												
Western Tanager	C												

Table 7. Checklist of Birds Observed in the Lower Kinnickinnic River Valley by Dr. Goddard

Common Loon
Pied-billed Grebe
Great Blue Heron
Green Heron
Common (American) Egret
American Bittern
Canadian Goose
Blue Goose
Mallard
Gadwall
Pintail
Green-wing Teal
Blue-wing Teal
American Widgeon (Baldplate)
Shoveler
Wood Duck
Ring-Necked Duck
Greater Scaup
Lesser Scaup
Common (American) Goldeneye
Bufflehead
Hooded Merganser
Common (American) Merganser
Red-breasted Merganser
Turkey Vulture
Sharp-skinned Hawk
Cooper's Hawk
Red-tailed Hawk
Red-shouldered Hawk
Broad-winged Hawk
Bald Eagle
Marsh Hawk
Osprey
Pigeon Hawk
Sparrow Hawk
Ruffed Grouse
Ring-necked Pheasant
Coot
Killdeer
Common (Wilson's) Snipe
Spotted Sandpiper
Solitary Sandpiper
Greater Yellowlegs
Lesser Yellowlegs
Pectoral Sandpiper
Great Horned Owl
Barred Owl
Nighthawk
Whip-poor-will
Chimney Swift
Ruby-throated Hummingbird
Belted Kingfisher
Flicker
Pileated Woodpecker
Red-bellied Woodpecker
Red-headed Woodpecker
Yellow-bellied Sapsucker
Hairy Woodpecker
Downy Woodpecker
Eastern Kingbird
Crested Flycatcher
Eastern Phoebe
Yellow-bellied Flycatcher
Alder Flycatcher
Least Flycatcher
Eastern Wood Pewee
Tree Swallow
Bank Swallow
Rough-winged Swallow
Barn Swallow
Cliff Swallow
Purple Martin
Blue Jay
Crow
Black-capped Chickadee
White-breasted Nuthatch
Brown Creeper
House Wren
Winter Wren
Catbird
Brown Thrasher
Robin
Wood Thrush
Hermit Thrush
Swainson's (Olive-backed) Thrush
Gray-checked Thrush
Veery
Bluebird
Blue-gray Gnatcatcher
Golden-crowned Kinglet

Table 7. Checklist of Birds Observed in the Lower Kinnickinnic River Valley by Dr. Goddard (Continued)

Woodcock
Ring-billed Gull
Herring Gull
Rock Dove
Mourning Dove
Yellow-billed Cuckoo
Black-billed Cuckoo
Warbling Vireo
Black & White Warbler
Tennessee Warbler
Orange-Crowned Warbler
Nashville Warbler
Yellow Warbler
Magnolia Warbler
Myrtle Warbler
Black-throated Green Warbler
Blackburnian Warbler
Chestnut-sided Warbler
Bay-breasted Warbler
Palm Warbler
Ovenbird
Northern Waterthrush (Grinnell's)
Connecticut Warbler
Yellow-throat
Wilson's Warbler
American Redstart
House (English) Sparrow
Bobolink
Eastern Meadowlark
Western Meadowlark
Red-winged Blackbird
Baltimore Oriole
Common Grackle
Brown-headed Cowbird
Scarlet Tanager
Cardinal
Rose-breasted Grosbeak
Indigo Bunting
Dickcissel
Evening Grosbeak
Purple Finch
Pine Siskin
Goldfinch
Towhee
Ruby-crowned Kinglet
Cedar Waxwing
Starling
Yellow-throated Vireo
Solitary Vireo
Red-eyed Vireo
Philadelphia Vireo
Savannah Sparrow
Grasshopper Sparrow
Vesper Sparrow
Slate-colored Junco
Tree Sparrow
Chipping Sparrow
Clay-colored Sparrow
Field Sparrow
White-crowned Sparrow
White-throated Sparrow
Harris' Sparrow
Fox Sparrow
Swamp Sparrow
Song Sparrow
Snow Bunting

Table 8. Summary of Chemical Analyses of St. Croix River Water, February through October, 1970 (NSP, 1971).

Item	Surface			Bottom		
	Minimum	Maximum	Mean	Minimum	Maximum	Mean
5-Day Biochemical Oxygen Demand - mg/l	0.20	5.20	1.82	0.20	6.25	1.92
Dissolved Oxygen - ppm	5.7	12.2	8.8	0.4	10.7	7.1
Hydrogen Ion Concentration - pH	7.1	8.7	7.9	7.2	8.5	7.8
Phosphorous - ppmP	0.008	0.109	0.027	0.005	0.097	0.032
Ammonia Nitrogen - ppmN	0.00	0.30	0.05	0.00	0.049	0.16
Organic Nitrogen - ppmN	0.00	1.08	0.63	0.00	1.27	0.68
Nitrate Nitrogen - ppmN	0.00	0.35	0.12	0.00	0.43	0.15
Nitrite Nitrogen - ppmN	0.000	0.008	0.003	0.000	0.008	0.004
Total (m) alkalinity - ppm $CaCO_3$	36	110	80	37	115	81
Phenolphthalein Alk - ppm $CaCO_3$	0.0	7	1.0	0.0	6	0.7
Total Hardness - ppm $CaCO_3$	45	114	87	46	122	88
Calcium Hardness - ppm $CaCO_3$	28	74	56	29	76	57
Chloride - ppm Cl	0.3	1.4	0.7	0.3	1.3	0.7
Sulfate - ppm SO_4	2.1	10.4	5.2	2.1	10.4	5.1
Total Residue - ppm	81	148	118	76	244	130
Non-Filterable Residue - ppm	1	21	6	1	114	18
Fixed Non-Filterable Residue - ppm	0	14	4	1	93	13
Turbidity - JTU	1.3	11.0	3.5	0.9	31.0	6.3
Color - Units	20	125	61	20	125	70
Temperature - ^oF	32.0	82.2	65.4	32.4	77.0	62.2

Table 9. Downstream Profile of Turbidity.

(D') = water depth sampled, in feet.

MN.R. Mile	Location	Left Bank FTU (D')	Mid-chan. FTU (D')	Right Bank FTU (D')	Notes
14.5	Upstream from clamshell dredge D.B. 771	25 (0') 31 (4')	21 (0') 27 (7')	20 (0') 30 (2')	Effect of dredging upon turbidity: dredge at left bank.
	Dredge D.B. 771				
	100' downstream from D.B. 771	23 (0') 31 (6')	27 (0') 57 (0') 71 (9') 86 (5')	49 (0') 60 (5')	
13.3	Upstream from Cargill terminal	27 (0') 41 (6') (bottom 8')	26 (0') 45 (11') (bottom 14')	19 (0') 26 (2') (bottom 4')	Area of heavy barge traffic.
13.3	Same spot: 0.5 min. after tow passed	29 (0') 42 (2') (bottom 3')	67 (0') 80 (11') (bottom 12')	53 (0') 59 (3') (bottom 6')	Effect of a tow (with four loaded barges headed downstream) upon turbidity.
13.3	Same spot: 10 min. after tow passed	36 (0') 45 (2') (bottom 3')	71 (0') 74 (10') (bottom 12')	37 (0') 62 (5') (bottom 6')	
13.3	Same spot 32.5 min. after tow passed	30 (0') 48 (2') (bottom 3')	29 (0') 64 (11') (bottom 12')	29 (0') 44 (3') (bottom 4')	
12.5	MBB transect	35 (0') 43 (3') (bottom 4')	38 (0') 55 (10') (bottom 11')	29 (0') 51 (2') (bottom 3')	Sampled about 20 min. after a tow passed upstream - two empty barges.
2.9	MCC transect	39 (0') 51 (3') (bottom 4')	44 (0') 76 (14') (bottom 15')	47 (0') 62 (3') (bottom 4')	Sampled about 35 min. after a tow passed upstream.
0.1	River mouth	46 (0') 56 (5') (bottom 6')	47 (0') 72 (12') (bottom 13')	32 (0') 54 (3') (bottom 4')	Sampled about 20 min. after a tow passed upstream.

Table 10. Planktonic algae species reported from Lake St. Croix (NSP, 1971).

PHYTOPLANKTON

Division Chrysophyta

Family Bacillariophyceae (diatoms)

Stephanodiscus astraea var. *minutula*
Asterionella formosa
Melosira granulata
M. granulata var. *currata*
M. granulata var. *angustissima*
Nitzschia acicularis
Synedra acus

Division Cyanophyta (blue-green)

Aphanizomenon flos-aquae
Microcystis aeruginosa
Anabaena flos-aquae

Division Chlorophyta (greens)

Ankistrodesmus falcatus
Scenedesmus quadricauda
Coelastrum proboscideum
Stichococcus sp.

Table 11. Attached algal species identified from artificial substrates placed in Lake St. Croix (NSP, 1971).

Species	Species
Blue-green Algae	Diatoms
cf. Chroococcus minimus	Achnanthes lanceolata
cf. Chroococcus minor	cf. Achnanthes minutissima
cf. Chroococcus minutus	Amphora ovalis
Lyngbya cf. diguetti	Asterionella formosa
Lyngbya sp. 6	Caloneis silicula
Lyngbya sp. 7	Cocconeis placentula
Oscillatoria geminata	Cyclotella sp. 2
Oscillatoria cf. redeckii	Cyclotella sp. 3
Oscillatoria sp. 4	Cyclotella sp. 4
Oscillatoria sp. 5	Cymbella caespitosa
Oscillatoria sp. 6	Cymbella ventricosa
Phormidium faveolarum	Cymbella sp. 2
Phormidium molle	Diatoma elongatum
Phormidium sp. 2	Diatoma vulgare
Phormidium sp. 3	cf. Eunotia (sp. 1)
Unknown	Fragilaria cf. capucina
Green Algae	Fragilaria construens
Ankistrodesmus cf. convolutus	Fragilaria pinnata
Ankistrodesmus falcatus	Gomphonema constrictum
Ankistrodesmus falcatus var. acicularis	Gomphonema cf. lanceolata
Chlamydomonas sp. 1	Gomphonema olivaceum
Chlamydomonas sp. 2	Gomphonema parvulum
Chlamydomonas sp. 3	cf. Gyrosigma accuminatum
Chlamydomonas sp. 4	cf. Melosira distans
Closterium cf. idiosporum	Melosira cf. italica
cf. geminella mutabilis	Melosira varians
Mougeotia sp. 1	cf. Melosira (sp. 1)
Mougeotia sp. 2	Navicula capitata
Scenedesmus bijuga	cf. Navicula radiosa
Scenedesmus dimorphus	Navicula tripunctata
Scenedesmus quadricauda var. longispina	Navicula cf. viridula
cf. Tetraedon minimum	Navicula sp. 2
Ulothrix cf. zonata	Navicula sp. 3
Unknown	Navicula sp. 4
	Navicula sp. 5

cf. = similar to

Table 11. Attached algal species identified from artificial substrates placed in Lake St. Croix (NSP, 1971). (Continued).

Species
Diatoms (Continued)
Navicula sp. 6
Navicula sp. 7
Navicula sp. 8
Navicula spp.
Nitzschia accicularis
Nitzschia dissipata
cf. Nitzschia holsatica
Nitzschia ignorata
Nitzschia sp. 3
Nitzschia sp. 7
Nitzschia sp. 11
Nitzschia sp. 12
Nitzschia sp. 15
Nitzschia spp.
cf. Peronia erinacea
Synedra acus
Synedra parasitica
Synedra rumpens
cf. Synedra tenera
Synedra ulna
Euglenoid Algae
Trachelomonas cf. pulchella
Trachelomonas volvocina
Trachelomonas sp. 1
Yellow-brown Algae (less diatoms)
Cryptomonad sp. 1
Cryptomonad sp. 2
Cryptomonad sp. 3
Unknown Algae
Coccoid form #1

Table 12. Benthic Animal Abundance (cont.)

A Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croix Rivers and Mile 815.3 to 857.3 of the Mississippi River (Continued)

MISSISSIPPI RIVER (Continued)

Upper St. Anthony Falls Pool (Continued)

Transect UAA, Mile 857.3 (Continued)

UAA : Mid-stream; Spring 1973; Coarse sand; 10 to 11', 12.3 maximum depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Polypedilum*	1	67.

UAA : Mid-channel; Summer 1973; Rocks, sand and gravel, 7' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Trichoptera	Hydropsychidae	*Hydropsyche*	22	64.
		Cheumatopsyche	6	
Ephemeroptera	Potamanthidae	*Potamanthus*	2	
	Heptageniidae	*Stenonema?* (damaged)	1	
Coleoptera	Elmidae		1	
Diptera	Chironomidae	*Polypedilum*	2	
		Rheotanytarsus	12	
	Pentaneurini		9	
		Polypedilum (pupa)	1	
	Tantytarsini (pupa)		2	
	Chironominae (unident. pupa)		1	
	Empididae	*Hemerodromia?*	4	
		Hemerodromia? (pupa)	2	
	Tipulidae	(unident. larva)	1	
	Simuliidae	*Simulium*	2	
		Simulium (pupa)	2	
	Chironomidae	*Rheotanytarsus ?*	1	

(in case, attached just behind head to cervical membrane of a Hydropsyche larva)

Table 12. Benthic Animal Abundance (cont.).

A Comparison of Spring and Summper Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croxi Rivers and Mile 815.3 to 857.3 of the Mississippi River (Continued)

MISSISSIPPI RIVER (Continued)

Upper St. Anthony Falls Pool (Continued)

Transect UBB, Mile 855.7

UBB : Left bank; Spring 1973; no organisms in sample

UBB : Burlington Northern RR bridge; 3rd pier from L/B; Summer 1973; Sand,rocks; 14' deep

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Ephemeroptera	Caenidae	*Caenis*	1	49.
Diptera	Chironomidae	*Cryptochironomus*	2	

UBB : Mid-channel; Summer 1973; Medium coarse sand

Diptera	Chironomidae	*Polypedilum*	1	65.

UBB : Mid-channel; Summer 1973; Sand and fine gravel with some plant debris; 13.75' depth

Diptera	Chironomidae	*Paratendipes*	1	54.

UBB : Right bank; Spring 1973; 4" d. chunk of cemet, very little fine sand, medium coarse sand; 2.7' deep, 12 yards from right bank

Trichoptera	Hydropsychidae	*Cheumatopsyche*	22	5.
		Hydropsyche	5	
		Macronemum	2	
Diptera	Chironomidae		2	
	Empididae		1	
Coleoptera	Elmidae		1	
	Elmidae	(Adults)	3	

UBB : Right bank; Summer 1973; no organisms

Table 12. Benthic Animal Abundance (cont.)
A Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croix Rivers and Mile 815.3 to 857.3 of the Mississippi River (Continued)

MISSISSIPPI RIVER (Continued)

Upper St. Anthony Falls Pool (Concluded)

Transect UCC; Mile 854.4

UCC: E, Left bank only; Spring 1973; Fine sand (on shelf), hardly any sediments; 16' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Oligochaeta			1	73.

UCC: Ekman, Left Bank; Summer 1973; no sample

UCC: Ekman, Mid-channel; Spring 1973; no sample

UCC: Ekman, Mid-channel; Summer 1973; Sand and gravel; 10' deep

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Trichoptera	Hydropsychidae	*Cheumatopsyche*	2	53.
Coleoptera	Elmidae		5	
Diptera	Chironomidae	*Stictochironomus*	1	
		Polypedilum	1	
		Eukiefferiella	1	

UCC: Mid- main channel; Summer 1973; Coarse sand with numerous small clam-shells; 18.5 - 19' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Cryptochironomus*	2	
		Polypedilum	4	
		Paratendipes	1	

Table 12. Benthic Animal Abundance (cont.)

A Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croix Rivers and Mile 815.3 to 857.3 of the Mississippi River (Continued)

MISSISSIPPI RIVER (Continued)

Lower St. Anthony Falls Pool

Transect LBB, Mile 853.4

LBB: Left bank; Spring 1973; 10 yards from left bank, and 325 yards from right bank; medium coarse sand with silt, plant and shell fragments; 3' depth

Class or order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Polypedilum*	3	69.
		Rheotanytarsus	1	

LBB: Left bank; Summer 1973; Sand, silt and pebbles; 3' deep

Class or order	Family	Genus	Organisms per sq ft	Sample Number
Trichoptera	Psychomyiidae	*Nyctiophylax*	3	
Ephemeroptera	Caenidae	*Caenis*		
	Heptageniidae	*Stenonema*	1	
Coleoptera	Elmidae		2	
Diptera	Chironomidae	*Dicrotendipes*	8	
		Glyptotendipes	6	
		Polypedilum	2	
		Cryptochironomus	5	
		Psectrotanypus	1	
Oligochaeta			5	

Table 12. Benthic Animal Abundance (cont.)

A Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota dn Lower St. Croix Rivers and Mile 815.3 to 857.3 of the Mississippi River (Continued)

MISSISSIPPI RIVER (Continued)

Lower St. Anthony Falls Pool (Concluded)

Transect LBB, Mile 853.4 (Continued)

LBB: Mid-channel; Spring 1973; A few pieces of bark, with Trichoptera larvae; 165 yards from Left bank and 155 yards from right bank, L guide wh

Class or order	Family	Genus	Organisms per sq ft	Sample Number
Trichoptera	Hydropsychidae	*Hydropsyche*	18	11.
		Hydropsyche (pupae)	2	
		Cheumatopsyche	9	
		Cheumatopsyche (pupae)	2	
	Philopotamidae	*Chimarra*	1	
Coleoptera	Elmidae		1	
Diptera	Chironomidae	*Endochironomus*	1	
		Microtendipes	1	
		Polypedilum	1	
	Chironominae	(unident., very small larva)	1	

LBB: Mid-channel; Summer 1973; Sand and pebbles; 14' deep

Diptera	Chironomidae	*Cryptochironomus*	2	
Oligochaeta			1	

LBB: Right bank; Spring 1973; Medium sand and silt (little current); 100 yards from right bank, 240 yards from left bank; 10' deep

Coleoptera	Elmidae		1	
Diptera	Chironomidae	*Polypedilum*	17	
		Chironomus	1	
Oligochaeta			11	

LBB: Right bank; Summer 1973; no sample

Table 12. Benthic Animal Abundance (cont)
A Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croix Rivers and Mile 815.3 to 857.3 of the Mississippi River (Continued)

MISSISSIPPI RIVER (Continued)

Pool 1

Transect 1AA, Mile 853.2

1AA: Left bank; Spring 1973; 62 yards from left bank and 127 yards from right bank; rocks with Trichoptera and 1 mayfly; 17.0' deep

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Trichoptera	Hydropsychidae	*Hydropsyche*	3	9.
		Cheumatopsyche	8	
Ephemeroptera	Potamanthidae	*Potamanthus*	1	
Diptera	Chironomidae	*Polypedilum*	2	

1AA: Left bank; Summer 1973; no sample

1AA: Mid-channel; Spring 1973; no sample

1AA: Mid-channel; Summer 1973; Coarse sand and gravel, rocks, fine sand; 11.0' depth

Ephemeroptera	Caenidae	*Caenis*	1	
	Potamanthidae	*Potamanthus*	1	
Ephemeroptera	(Unident. damaged nymph)		1	
Trichoptera	Hydropsychidae	*Cheumatopsyche*	3	
	Psycomyiidae	(Unident. damaged larva)	1	
Coleoptera	Elmidae		2	
Diptera	Chironomidae	*Polypedilum*	3	
		Cryptochironomus	2	
	Tanytarsini		2	
	Pentaneurini		4	

Table 12. Benthic Animal Abundance (cont.)
A Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croix Rivers and Mile 815.3 to 857.3 of the Mississippi River (Continued)

MISSISSIPPI RIVER (Continued)

Pool 1 (Continued)

1AA: Right bank; Spring 1973; 20 yards to right bank and 145 yards to left bank; Rocks with 1 mayfly nymph; 13.0' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Trichoptera	Hydropsychidae	*Hydropsyche*	4	7.
Plecoptera	Perlodidae	*Isoperla*	1	
Ephemeroptera	Heptageniidae	*Stenonema*	1	
Diptera	Chironomidae	*Polypedilum*	1	
	Orthocladiinae	(Unident. pupa)	1	

1AA: Right-bank; Summer 1973; no sample

Transect 1BB, Mile 850.6

1BB: Left-bank; Spring 1973; 8 yards to spoil on left bank, 225 yards to right bank tree; Rock, gravel, sand and silt; 5.5' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Trichoptera	Hydropsychidae	*Cheumatopsyche*	1	6.
Diptera	Chironomidae	*Cryptochironomus*	1	
Oligochaeta	Tubificidae		12	

1BB : Left bank; Summer 1973; Fine sand, silt, rocks; 8.5' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Trichoptera	Hydropsychidae	*Cheumatcpsyche*	1	
Diptera	Chironomidae	*Cryptochironomus*	1	
Oligochaeta			3	

Table 12. Benthic Animal Abundance (cont.)

A Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croix Rivers and Mile 815.3 to 857.3 of the Mississippi River (Continued)

MISSISSIPPI RIVER (Continued)

Pool 1 (Continued)

Transect 1BB; Mile 850.6 (Continued)

1BB : Mid-channel; Spring 1973; 135 yards to left bank, 76 yards to right bank spoil and 54 more yards to base of bluff and tree; No record of substrate type; 15.5' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Coleoptera	Elmidae		1	17.
Diptera	Chironomidae	*Polypedilum*	3	
		Paratendipes	3	
	Ceratopogonidae ?	(Unident. larva)	1	
Pelecypoda (clams)	Sphaeriidae	*Sphaerium*	1	

1BB : Mid-channel; Summer 1973; No organisms

1BB: Right bank; Spring 1973; No sample

1BB : Right bank; Summer 1973; No sample

Transect 1XX, Mile 851.1

1XX : Left bank; Spring 1973; No sample

1XX : Left bank; Summer 1973; 150' from left bank; Sand and a couple bark fragments; 12.5' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Coleoptera	Elmidae	(damaged larva)	1	40.

1XX: Mid-channel; Spring 1973; no sample

1XX: Mid-channel; Summer 1973; Sand and bark fragments (pine), shell fragments; 14' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Paratendipes*	5	24.
Pelecypoda (clams)		*Sphaerium*	1	
Gastropoda (snails)		*Planorbula* (not alive)	1	
Oligochaeta			1	

Table 12. Benthic Animal Abundance (cont.)

A Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croix Rivers and Mile 815.3 to 857.3 of the Mississippi River (Continued)

MISSISSIPPI RIVER (Continued)

Pool 1 (Continued)

Transect 1XX, Mile 851.1 (Continued)

1XX: Right bank; Spring 1973; No sample

1XX: Right bank; Summer 1973; 35' to right bank; Shell fragments and bark, gravel and coarse sand; 15.5' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Trichoptera	Hydropsychidae	*Cheumatopsyche*	1	19.
Diptera	Chironomidae	*Cryptochironomus*	5	
		Polypedilum	2	
	Pentaneurini		1	
Pelecypoda (clams)	Unionidae	*Actinonaias*	1	

Transect 1CC, Mile 848.0

1CC: Left-bank; Spring 1973; 20 yards to left-bank; Fine sand, few 1" stones, sticks; 5.5' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Polypedilum*	23	16.
		Paratendipes	6	
		Phaenopsectra	6	
		Cryptochironomus	1	
		Chironomus	2	
	Psychodidae	*Psychoda*	1	
Oligochaeta			15	

1CC: Left bank; Summer 1973; 100' from left bank; Fine sand and silt, sewer smell in sediments; 4.0' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Cryptochironomus*	1	46.
		Chironomus	2	
		Polypedilum	1	
Oligochaeta			1	

Table 12. Benthic Animal Abundance (cont.)
A
Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croix Rivers and Mile 815.3 to 857.3 of the Mississippi River (Continued)

MISSISSIPPI RIVER (Continued)

Pool 1 (Concluded)

Transect 1CC, Mile 848.0 (Continued)

1CC: Mid-channel; Spring 1973; No sample

1CC: Mid-channel; Summer 1973

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Chironomus*	3	23.
Oligochaeta			2	

1CC: Right bank; Spring 1973; No sample

1CC: Right bank; Summer 1973; No sample

Pool 2

Transect 2AA, Mile 847.4

2AA: East channel, Left bank; Spring 1973; 59 yards from left bank, 300 yards from right bank; Rocks; 9.1' depth

Trichoptera	Hydropsychidae	*Hydropsyche*	3	10.
		Cheumatopsyche	5	
	Hydropsychidae	(Unident. pupae)	9	
		(Damaged larvae)	2	
	Psychomyiidae	*Polycentropus*	1	
Ephemeroptera	Potamanthidae	*Potamanthus*	2	
Diptera	Chironomidae	*Phaenopsectra*	1	
	Tanytarsini		3	
Hirudinea (leeches)			1	

2AA: East channel; Summer 1973; 15 feet from island; Rocks and coarse gravel; 3.5-5.0' depth

Coleoptera	Elmidae		1	
Hirudinea (leeches)			3	

Table 12. Benthic Animal Abundance (cont.)

A Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croix Rivers and Mile 815.3 to 857.3 of the Mississippi River (Continued)

MISSISSIPPI RIVER (Continued)

Pool 2 (Continued)

Transect 2AA, Mile 847.4 (Continued)

2AA: Rock Scrapings; Left channel, 15 feet from island; Rocks and coarse gravel 3.5-5.0' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Ephemeroptera	Potamanthidae	*Potamanthus*	1	34.
Trichoptera	Psychomyiidae	*Polycentropus*	1	
Diptera	Chironomidae	*Dicrotendipes ?*	1	
	Chironomidae ?	(unident. egg mass)	1	
Hirudinea (leech)			1	

2AA: Mid-channel; Spring 1973; No sample

2AA: Mid-channel by lock; Rock scrapings; Summer 1973; Rocks encrusted with algae, etc.

Diptera	Chironomidae	*Polypedilum*	1	59.

2AA: Right bank; Spring 1973; No organisms

2AA: Right bank; Summer 1973; no organisms

Transect 2BB, Mile 831.7

2BB: Left bank; Spring 1973; 30 yards from left bank; Gelatinous, with sand; 4.5' depth

Diptera	Chironomidae	*Polypedilum*	6	71.
		Phaenopsectra	6	
		Chironomus	1	
		Stictochironomus	1	
	Empididae	(Unident. larva)	1	

2BB: Left bank; Summer 1973; Mostly sludge, silt and organic clay; 11.1' depth

Diptera	Chironomidae	*Procladius*	6	35.
Oligochaeta			32	

Table 12. Benthic Animal Abundance (cont.)

A Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croix Rivers and Mile 815.3 to 857.3 of the Mississippi River (Continued)

MISSISSIPPI RIVER (Continued)

Pool 2 (Continued)

Transect 2BB, Mile 831.7 (Concluded)

2BB: Mid-channel; Spring 1973; 10 yards from right bank and 250 yards to left bank; 23' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Plecoptera	Perlodidae	*Isoperla*	1	8.
Ephemeroptera	Ephemeridae	*Pentagenia*	1	
	Potamanthidae	*Potamanthus*	1	
Coleoptera	Elmidae		2	
Diptera	Chironomidae	*Xenochironomus*	18	
	Pentaneurini		3	

2BB: Mid-channel; Summer 1973

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Chironomus*	4	29.
		Procladius	1	
	Chaoboridae	*Chaoborus*	6	
Oligochaeta			37	

2BB: Mid-channel; Summer 1973

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Oligochaeta			2	60.

2BB: Right bank; Spring, 1973; No sample

2BB: Right bank; Summer 1973; No sample

Table 12. Benthic Animal Abundance (cont.)

A Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croix Rivers and Mile 815.3 to 857.3 of the Mississippi River (Continued)

MISSISSIPPI RIVER (Continued)

Miscellaneous Pool 2 Sites

Pool 2: Right bank of back channel, Newport Island; Summer 1973

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Procladius*	2	47.
Oligochaeta				

Chute behind Island 2CC; Right-bank; Downstream from 827.7; Summer 1973; Clay, silt and some sand; 4' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Oligochaeta	(Many fragements)		47	28.
Nemertea (proboscis worm)			1	

Mile 827.7 : Left bank backwater; Upstream from spoil; Summer 1973; Sand with 1/8" silt on top; 6.5' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Oligochaeta			2	63.

Grey Cloud Slough at twin fill; Summer 1973; Organic mud; 18' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Tanypus*	2	31.
		Chironomus?	1	
	Chaoboridae	*Chaoborus*	7	

Baldwin Lake; Downstream from spoil; Summer 1973; About 1" of silt on 2' deep sand and mud

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Procladius*	2	48.
Oligochaeta			4	

Table 12. Benthic Animal Abundance (cont.)

A Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croix Rivers and Mile 815.3 to 857.3 of the Mississippi Rivers (Continued)

MISSISSIPPI RIVER (Continued)

Pool 2 (Continued)

Transect 2YY, Mile 821.4

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
2YY :"3A"; Spring 1973; 135 yards to right bank; Organic mud, much silt, some fine grit; 3.2' depth				
Diptera	Chironomidae	*Psectrotanypus*	1	1.
		Procladius	9	
		Cryptochironomus	1	
Oligochaeta	Tubificidae		54	
Oligochaeta		(Immatures and/or small)	23	
2YY :"3A"; Right-bank; Summer 1973; Soft mud; 3.5' depth				
Diptera	Chironomidae	*Procladius*	1	36.
Oligochaeta			5	
2YY :"3B"; Spring 1973; no sample				
2YY :"3B"; Summer 1973; Soft mud; 3' depth				
Diptera	Chironomidae	*Procladius*	3	41.
Oligochaeta			8	
2YY: "3C"; Spring 1973		Note: "3C" is mid-channel		
Diptera	Chironomidae	*Procladius*	19	15.
		Tanypus	2	
Oligochaeta			14	

Table 12. Benthic Animal Abundance (cont.)

A Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croix River and Mile 815.3 to 857.3 of the Mississippi River (Continued)

MISSISSIPPI RIVER (Concluded)

Pool 2 (Concluded)

Transect 2YY, Mile 821.4 (Continued)

2YY:"3C"; Summer 1973; Medium coarse sand with 1/8" silt layer on top; 12.5' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Oligochaeta			2	50.

Transect 2CC, Mile 815.5

2CC: Left bank; Spring 1973; 7 yards from left bank, 1 mile to right bank, 750 yards to upstream tip of Buck Island;Black clay mud (kept shape), sl anaerobic; 15.5' depth

Oligochaeta			94.	14.

2CC: Left bank; Summer 1973; No sample

2CC: Mid-channel; Spring 1973; 155 yards from left bank; 3 tries and Petersen dredge wouldn't trip, anchor came up with partly decayed leaves, sticks, large branch and sludge attached; 28' depth

Diptera	Chironomidae	*Procladius*	8	68.

2CC: Mid-channel; Summer 1973

Diptera	Chironomidae	*Procladius*	8	27.
Oligochaeta			11	

2CC: Right bank; Spring 1973; No sample

2CC: Right bank; Summer 1973; No sample

Table 12. Benthic Animal Abundance (cont.)

A Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croix Rivers and Mile 815.3 to 857.3 of the Mississippi River (Continued)

MINNESOTA RIVER

Transect MAA, Mile M24.8

MAA : Left Bank; Spring 1973; No organisms

MAA: Left bank; Rock Scrapings; Summer 1973; 40' from left bank; 1-2" silt over gelatinous mud, smelled slightly of decay; 5.5' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Trichoptera	Hydropsychidae	*Cheumatopsyche*	1	21.
	Hydropsychidae	(Unident. damaged pupa)	1	
Coleoptera	Elmidae		1	
Diptera	Chironomidae	*Glyptotendipes*	9	
		Glyptotendipes (pupae)	2	
	Nematocera	(Unident. damaged pupae)	2	

MAA: Mid-channel; Spring 1973; No sample

MAA: Mid-channel; Summer 1973; No sample

MAA: Right bank; Spring 1973; No sample

MAA: Right bank; Summer 1973; No organisms

Transect MBB, Mile M13.0

MBB : Left bank; Spring 1973; No organisms

MBB: Left bank; Summer 1973; 6' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Polypedilum*	1	57.

Table 12. Benthic Animal Abundance (cont.)

A

Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croix Rivers and Mile 815.3 to 857.3 of the Mississippi River (Continued)

MINNESOTA RIVER (Continued)

Transect MBB, Mile M13.0 (Continued)

MBB: Mid-channel; Spring 1973; No sample

MBB: Mid-channel; Summer 1973; No record of substrate; 8' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Tanypus*	2	25.
		Procladius	5	
Oligochaeta			11	

MBB: Right bank; Spring 1973; 12 yards from right bank; 120 yards from left bank; Coarse sand and clay pellets; 7.5' depth

Diptera	Chironomidae	*Cryptochironomus*	1	18.

MBB: Right bank; Summer 1973; Fine sand with clay lumps, silt layer on top; 3' depth

Diptera	Chironomidae	*Cryptochironomus*	1	18.

MBB: Right bank; Summer 1973; Fine sand with clay lumps, silt layer on top; 3' depth

Oligochaeta			1	51.

Transect MCC, Mile M3.0

MCC: Left-bank; Spring 1973; No organisms

MCC: Left-bank; Summer 1973; No sample

Table 12. Benthic Animal Abundance (cont.)

A Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St.Croix Rivers and Mile 815.3 to 857.3 of the Mississippi River (Continued)

MINNESOTA RIVER (Concluded)

Transect MCC, Mile M3.0 (Continued)

MCC: Mid-channel; Spring 1973; No sample

MCC: Mid-channel; Summer 1973; Fine sand with shallow layer of silt; 12' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Procladius*	2	30.
Oligochaeta			28	

MCC: Right bank; Spring 1973; Ekman dredge (small amount of sand, much water) 5 yards to right bank; 5' depth

Oligochaeta			1	72.

MCC: Right bank; Summer 1973; Clay silt and some sand; 4' depth

Oligochaeta			9	38.

ST. CROIX RIVER

Transect SAA, Mile SC24.8

SAA: Left bank; Spring 1973; 10 yards to left bank; Substrate not recorded; 9.5' depth

Oligochaeta			1	78.

SAA: Left bank; Summer 1973; No sample

Table 12. Benthic Animal Abundance (cont.)

A Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croix Rivers and Mile 815.3 to 857.3 of the Mississippi River (Continued)

ST. CROIX RIVER (Continued)

Transect SAA, Mile SC24.8 (Continued)

SAA: Mid-channel; Spring 1973; Substrate not recorded; 5.2' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Micropsectra*	1	70.
	Ceratopogonidae ?	(Unident. larva)	1	
Oligochaeta			1	

SAA: Mid-channel; Summer 1973; Clay and mud (organic?); 1 chironomid; 22' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Tipulidae		1	22.
	Chironomidae	*Xenochironomus*	4	

SAA; Right bank; Spring 1973; No sample

SAA: Right bank; Mid backwater; Summer 1973; Fine sand overlain with silt; Middle of bay; 3' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Procladius*	2	33.

Transect SXX, Mile SC16.0

SXX: Left bank; Spring 1973; 560 yards from left bank; Shallows; 10.3' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Ephemeroptera	Caenidae	*Caenis*	1	74.
Diptera	Chironomidae	*Cryptochironomus*	2	
		Potthastia	1	
Oligochaeta			1	

SXX: Left bank; Summer 1973; Medium to fine sand, wood fragments and clam-shell; Middle of the bay; 7.5' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Cryptochironomus*	1	43.
	Chaoboridae	*Chaoborus*	1	

Table 12. Benthic Animal Abundance (cont.)

A Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croix Rivers and Mile 815.3 to 857.3 in the Mississippi River (Continued)

ST. CROIX RIVER (Continued)

Transect SXX, Mile SC 16.0 (Continued)

SXX: Mid-channel; Spring 1973; 1000 yards from left bank, 180 yards from right bank; Coarse red sand; 16.3' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Polypedilum*	1	75.
		Stictochironomus	1	
		Paracladopelma	1	
		Paracladopelma? (very small)	2	
Pelecypoda (clams)		*Pisidium*	10	
Gastropoda (snails)		*Stagnicola ?* (very small)	1	

SXX: Mid-channel; Summer 1973; No record of substrate; 15.7' depth

Oligochaeta			2	39.

SXX: Right bank; Spring 1973; No sample

SXX: Right bank; Summer 1973; No sample

Transect SBB, Mile SC 12.3

SBB: Left bank; Spring 1973; No organisms

SBB: Left bank; Summer 1973; No organisms

SBB: Mid-channel; Spring 1973; No sample

SBB: Mid-channel; Summer 1973; No organisms

Table 12. Benthic Animal Abundance (cont.)

A Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croix Rivers and Mile 815.3 to 857.3 in the Mississippi River (Continued)

ST. CROIX RIVER (Continued)

Transect SBB, Mile (Continued)

SBB : Right Bank; Spring 1973; 1400 yards from left bank, 40 yards from right bank; Clams, snails, gravel to 5", coarse sand; 11.5' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Eggs (?) of unknown organism on pebble				
Diptera	Chironomidae	*Tanytarsini*	2	4.
Oligochaeta	Lumbriculidae		1	
Nematoda (roundworms)			1	

SBB: Right bank; Summer 1973; No sample

Transect SYY, Mile SC 6.4

SYY: Left bank; Spring 1973; Fine sand, sticks and plant debris; Backwater; 2.2 yards from right-bank; 3.0' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Cryptochironomus*	5	3.
		Chironomus	8	
		Paratenaipes	7	
		Psectrotanypus	1	
		Procladius	8	
		Micropsectra	3	
		Harnischia	1	
		Polypedilum	4	
		Cladotanytarsus ([illegible] very small)	46	
	Ceratopogonidae	*Palpomyia ?*	3	
Oligochaeta	Tubificidae		2	

SYY: Left bank; Shallow; Summer 1973; Just downstream from Mo. and Kinnikinnick; Sand with a little silt; 3' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Cryptochironomus*	2	52.
		Polypedilum	2	
	Tanytarsini		1	
Oligochaeta			2	

Table 12. Benthic Animal Abundance (cont.)

A Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croix Rivers and Mile 815.3 to 857.3 of the Mississippi River (Continued)

ST. CROIX RIVER (Continued)

Transect SYY, Mile SC6.4 (Continued)

SYY: Mid-channel; Spring 1973

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Odonata	Gomphidae	(Unident. small nymph)	1	12.
Coleoptera	Elmidae		1	
Diptera	Chironomidae	*Polypedilum*	2	
		Cryptochironomus	2	
	Ceratopogonidae	*Palpomyia*	1	
Oligochaeta			123	

SYY: Kinny mid-channel; Summer 1973; Medium to fine sand; 15.3' depth

Oligochaeta			1	44.

SYY: Right bank; Spring 1973; 12 yards from right bank; 1-2" stones, very little coarse sand; Depth not recorded

Diptera	Chironomidae		1	76.
Egg? (of a fish?)			1	

SYY: Right bank; Summer 1973; About 30' from right bank; Rocks, pebbles, sand and plant debris; 14.5-15' depth

Diptera	Chironomidae	*Glyptotendipes*	1	55.
		Glyptotendipes (pupa)	1	

Transect SCC, Mile__________

SCC: Left bank; Spring 1973; 30 yards from left bank, 700 yards from right bank; 12' depth

Coleoptera	Elmidae		1	77.

SCC: Left bank; Summer 1973; No sample

Table 12. Benthic Animal Abundance (cont.)

A

Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croix Rivers and Mile 815.3 to 857.3 of the Mississippi River (Concluded)

ST. CROIX RIVER (Concluded)

Transect SCC, Mile (Continued)

SCC: Mid-channel; Spring 1973; No sample

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera		(Unident. fragments)	1	62.
Oligochaeta			1	
Nemertea (proboscis worm)			1	

SCC: Right bank; Spring 1973; 5 yards from right bank; 1 rock 3" x 6" with worm-like encrustations; 3.5' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Coleoptera	Elmidae		1	66.

SCC: Right bank; Summer 1973; No sample

Table 12. Benthic Animal Abundance (cont.)

B Benthic Macroinvertebrates* of the Navigable Twin Cities Rivers, Collected on Standard and Special Transects in 1973. (Arranged alphabetically within phyla).

List of Abbreviations

AA,BB,CC	Standard transects, in downstream order
XX,YY	Special Transects, in downstream order
U,L,1,2	Upper and lower St. Anthony Falls Pools, and Pools 1 and 2, respectively
M, S	Minnesota and St. Croix Rivers, respectively
Spr	Spring: April and May
Su	Summer: August and September
D/S, U/S	Downstream, upstream
ch	Channel
19.	Serial number of sample

PHYLUM NEMERTEA Proboscis worms

2CC Su 28. SCC Su 62.

PHYLUM NEMATODA Roundworms

SBB Spr 4.

PHYLUM ANNELIDA Segmented worms

Class Hirudinea Leeches

2AA Spr 10. 2AA L Ch 34. 2AA L ch Su 45.

Class Oligochaeta Aquatic earthworms

Family Lumbriculidae

SBB Spr 4.

Family Tubificidae

2YY Spr 1. 3YY Spr 3. 1BB Su 6.

Unidentifiable oligochaetes

SYY	Spr	12.	LBB	Spr	13.	2CC	Spr	14.	2YY	Spr	15.
1CC	Spr	16.	1XX	Su	24.	1CC	Su	23.	MBB	Su	25.
1BB	Su	26.	2CC	Su	27.	2CC	Su	28.	2BB	Su	29.
MCC	Su	30.	2BB	Su	35.	2YY	Su	36.	LBB	Su	37.
MCC	Su	38.	SXX	Su	39.	SYY	Su	44.	1CC	Su	46.

*Benthic macroinvertebrates: bottom-dwelling nonmicroscopic animals without backbones.

Table 12. Benthic Animal Abundance (cont.)

B Benthic Macroinvertebrates of the Navigable Twin Cities Rivers, Collected on Standard and Special Transects in 1973. (Continued).

PHYLUM ANNELIDA Segmented worms (Continued)

Class Oligochaeta (Continued)

Unidentifiable oligochaetes (Continued)

2	Su	47.	2	Su	48.	2YY	Su	50.	MBB	Su	51.
SYY	Su	52.	LBB	Su	58.	2BB	Su	60.	SCC	Su	62.
2		63.	SAA	Spr	70.	MCC	Spr	72.	UCC	Spr	73.
SXX	Spr	74.	SAA	Spr	78.	2YY	Su	41.			

Immatures and/or small Oligochaeta

2YY Spr 1.

PHYLUM ARTHROPODA Crustaceans, Insects and Spiders

Class Insecta Insects

Order Coleoptera Beetles

Family Elmidae

UBB	Spr	5.	2BB	Spr	8.	LBB	Spr	11.	SYY	Spr	12.
LBB	Spr	13.	1BB	Spr	17.	UAA	Su	20.	MAA	Su	21.
1AA	Su	32.	LBB	Su	37.	1XX	Su	40.	2AA	Su	45.
UCC	Su	53.	UAA	Su	64.	SCC	Spr	66.	SCC	Spr	77.

Order Diptera Flies, Mosquitoes and Midges

Family Ceratopogonidae (?) Unident. larva
1BB Spr 17.

Family Ceratopogonidae

Genus *Palpomyia (?)*
SYY Spr 3.

Genus *Palpomyia*
LBB Spr 13.

Family Chaoboridae

Genus *Chaoborus*

2BB	Su	29.	2*	Su	31.	SXX	Su	43.

*Special transect: in Grey Cloud channel at discharge from Mooers Lake.

Table 12. Benthic Animal Abundance (cont.)

B Benthic Macroinvertebrates of the Navigable Twin Cities Rivers, Collected on Standard and Special Transects in 1973 (Continued)

PHYLUM ARTHROPODA (Continued)

Class Insecta (Continued)

Order Diptera (Continued)

Family Chironomidae (?) Unident. larva

SAA	Spr	70.									

Family Chironomidae (?) Unident. egg mass

2AA		34.									

Family Chironomidae Unident. pupae

UAA	Su	20.	UAA	Su	64.						

Family Chironomidae

Subfamily Chironominae

LBB	Spr	11.									

Genus *Chironomus*

SYY	Spr	3.	LBB	Su	13.	1CC	Spr	16.	UAA	Su	20.
1CC	Su	23.	2BB	Su	29.	2*	Su	31.	1CC	Su	46.
2BB	Spr	71.									

Genus *Cladotanytarsus*

SYY	Spr	3.									

Genus *Cryptochironomus*

2YY	Spr	1.	SYY	Spr	3.	1BB	Su	6.	SYY	Spr	12.
1CC	Spr	16.	MBB	Spr	18.	1XX	Su	19.	1BB	Su	26.
1BB	Su	32.	LBB	Su	37.	UCC	Su	42.	SXX	Su	43.
1CC	Su	46.	UBB	Su	49.	SYY	Su	52.	LBB	Su	58.
SXX	Spr	74.									

Genus *Diamesa*

SYY	Spr	76.									

Genus *Dicrotendipes (?)*

2AA		34.									

Genus *Dicrotendipes*

LBB	Su	37.									

*Special transect: in Grey Cloud channel at discharge from Mooers Lake.

Table 12. Benthic Animal Abundance (cont.)

B Benthic Macroinvertebrates of the Navigable Twin Cities Rivers, Collected on Standard and Special Transects in 1973 (Continued)

PHYLUM ARTHROPODA (Continued)

Class Insecta (Continued)

Order Diptera (Continued)

Family Chironomidae (Continued)

Genus *Endochironomus*
LBB Su 11.

Genus *Eukiefferiella*
UCC Su 53.

Genus *Glyptotendipes*

MAA	Su	21.	LBB	Su	37.	SYY	Su	55.

Genus *Harnischia*
SYY Spr 3.

Genus *Micropeectra*

SYY	Spr	3.	SAA	Spr	70.

Genus *Microtendipes*
LBB Su 11.

Subfamily Orthocladiinae
1AA Su 7.

Genus *Paracladopelma*
SXX Spr 75.

Genus *Paratendipes*

SYY	Spr	3.	1CC	Spr	16.	1BB	Spr	17.	1XX	Su	24.
UCC	Su	42.	UBB	Su	54.						

Genus *Pentaneurini*

UBB	Spr	5.	2BB	Spr	8.	1XX	Su	19.	UAA	Su	64.
1AA	Su	32.									

Genus *Phaenopsectra*

2AA	Spr	10.	1CC	Spr	16.	2BB	Spr	71.

Table 12. Benthic Animal Abundance (cont.)

B Benthic Macroinvertebrates of the Navigable Twin Cities Rivers, Collected on Standard and Special Transects in 1973 (Continued)

PHYLUM ARTHROPODA (Continued)

Class Insecta (Continued)

Order Diptera (Continued)

Family Chironomidae (Continued)

Genus *Polypedilum*

UAA	Spr	2.	SYY	Spr	3.	1AA	Spr	7.	1AA	Spr	9.
LBB	Spr	11.	SYY	Spr	12.	LBB	Spr	13.	1CC	Spr	16.
1BB	Spr	17.	1XX	Su	19.	UAA	Su	20.	1AA	Su	32.
LBB	Su	37.	UCC	Su	42.	1CC	Su	46.	SYY	Su	52.
UCC	Su	53.	MBB	Su	57.	2AA	Su	59.	UAA	Su	64.
UBB	Spr	65.	UAA	Spr	67.	LBB	Spr	69.	2BB	Spr	71.
SXX	Spr	75.									

Genus *Polypedilum* (pupa)

UAA	Spr	64.

Genus *Potthastia*

SXX	Spr	74.

Genus *Procladius*

2YY	Spr	1.	SYY	Spr	3.	2YY	Spr	15.	MBB	Su	25.
2CC	Su	27.	2BB	Su	29.	MCC	Su	30.	SAA	Su	32.
2BB	Su	35.	2YY	Su	36.	2YY	Su	41.	2*	Su	47.
2**	Su	48.	2CC	Spr	68.						

Genus *Psectrotanypus*

2YY	Spr	1.	LBB	Su	37.	SYY	Spr	3.

Genus *Rheotanytarsus (?)*

UAA	Spr	64.

Genus *Rheotanytarsus*

UAA	Spr	20.	LBB	Su	69.	UAA	Su	64.

Genus *Stictochironomus*

UCC	Su	53.	2BB	Spr	71.	SXX	Spr	75.

Genus *Tanypus*

2YY	Spr	15.	MBB	Su	25.	2†	Su	31.

*Right bank in West channel, Newport Island, mile 831.0.
**Baldwin Lake.
†Special transect: in Grey Cloud channel at discharge from Mooers Lake.

Table 12. Benthic Animal Abundance (cont.)

B Benthic Macroinvertebrates of the Navigable Twin Cities Rivers, Collected on Standard and Special Transects in 1973 (Continued)

PHYLUM ARTHROPODA (Continued)

Class Insecta (Continued)

Order Diptera (Continued)

Family Chironomidae (Continued)

Genus *Tanytarsini*

SBB	Spr	4.	2AA	Su	10.	1AA	Su	32.	SYY	Su	52.
UAA	Su	64.									

Genus *Xenochironomus*

2BB	Spr	8.	SAA	Su	22.

Family Empididae (Unident. larva)

UAA	Su	64.	2BB	Spr	71.

Family Empididae

UBB Spr 5.

Genus *Hemerodromia (?)*

UAA Su 20. UAA Su 64. Both samples also contain a pupa

Family Nematocera (Unident. damaged pupa)

MAA Su 21.

Family Psychodidae

Genus *Psychoda*

1CC Spr 16.

Family Simuliidae (very small larvae)

UAA Spr 2.

Family Simuliidae

Genus *Simulium*

UAA Su 64.

Genus *Similum* (pupa)

UAA Su 64.

Family Tipulidae

SAA Su 22.

Diptera (unident. fragment)

SCC Su 62.

Table 12. Benthic Animal Abundance (cont.)

B Benthic Macroinvertebrates of the Navigable Twin Cities Rivers, Collected on Standard and Special Transects in 1973 (Continued)

PHYLUM ARTHROPODA (Continued)

Class Insecta (Continued)

Order Ephemeroptera Mayflies

Family Caenidae

Genus *Caenis*

UAA	Su	20.	1AA	Su	32.	LBB	Su	37.	SXX	Spr	74.
UBB	Su	49.									

Family Ephemeridae

Genus *Pentagenia*

2BB	Spr	8.

Family Heptageniidae

Genus *Stenonema*

1AA	Spr	7.	UAA	Su	64.	LBB	Su	37.

Family Potamanthidae

Genus *Potamanthus*

2BB	Spr	8.	1AA	Spr	9.	2AA	Spr	10.	1AA	Su	32.
2AA		34.	UAA	Su	64.						

Order Odonata Dragonflies and Damselflies

Family Gomphidae (Unident. small nymph)

SYY	Spr	12.

Order Plecoptera Stoneflies

Family Chloroperlidae

Genus *Hastaperla*

UAA	Spr	2.

Family Perlodidae

Genus *Isoperla*

1AA	Spr	7.	2BB	Spr	8.

Table 12. Benthic Animal Abundance (cont.)

B Benthic Macroinvertebrates of the Navigable Twin Cities Rivers, Collected on Standard and Special Transects in 1973 (Continued)

PHYLUM ARTHROPODA (Continued)

Class Insecta (Continued)

Order Plecoptera (Continued)

Family Perlidae

Genus *Paragentina*

UAA	Spr	2.									

Genus *Phasganophora*

UAA	Spr	20.									

Order Trichoptera Caddis Flies

Family Hydropsychidae

Genus *Cheumatopsyche*

UAA	Spr	2.	UBB	Spr	5.	1BB	Spr	6.	1AA	Spr	9.
2AA	Spr	10.	LBB	Spr	11.	1XX	Su	19.	UAA	Su	20.
MAA	Su	21.	UCC	Su	53.	1BB	Su	26.	1AA	Su	32.
UAA	Su	64.									

Genus *Hydropsyche*

UAA	Spr	2.	UBB	Spr	5.	1AA	Spr	7.	1AA	Spr	9.
2AA	Spr	10.	LBB	Spr	11.	UAA	Su	20.	UAA	Su	64.

Genus *Macronemum*

UBB	Spr	5.	UAA	Spr	20.						

Family Hydropsychidae (Unidentified pupae; some damaged)

2AA	Spr	10.	UAA	Su	20.	MAA	Su	21.			

Family Hydropsychidae (Damaged or very immature)

UAA	Spr	2.									

Family Philopotamidae

Genus *Chimarra*

LBB	Spr	11.									

Table 12. Benthic Animal Abundance (cont.)

B Benthic Macroinvertebrates of the Navigable Twin Cities Rivers, Collected on Standard and Special Transects in 1973 (Continued)

PHYLUM ARTHROPODA (Continued)

Class Insecta (Continued)

Order Trichoptera (Continued)

Family Psychomyiidae

Genus *Nyctiophylax*
LBB Su 37.

Genus *Polycentropus*
2AA Spr 10. 2AA 34.

Order Trichoptera (Unidentified very small larva)
UAA Spr 20.

PHYLUM MOLLUSCA Snails and Clams

Order *Gastropoda*

Family *Lymnaeidae*

Genus *Stagnicola (?)* (Very small)
SXX Spr 75.

Order Pelecypoda

Family Unionidae

Genus *Actinonaias*
1XX Su 79.

Family Sphaeriidae

Genus *Pisidium*
SXX Spr 75.

Genus *Sphaerium*
1BB Spr 17. 1XX Su 24.

EGGS (?) of unknown organism on pebble
SBB Spr 4.

EGG(?) of a fish
SYY Spr 76.

Table 13. Macroinvertebrate Animals (NSP, 1971)

SPONGE
- Spongillidae g. sp. 1

FLATWORMS
- Prostoma rubrum
- Dugesia tirrina

BRYOZOANS (=Ectoprocta)
- Plumatella repens
- Paludicella articulata
- Hyalinella punctata
- Pectinatella magnifica
- Lophopus crystallinus

HORSEHAIR WORM
- Gordius sp. 1

WORMS
- Tubifex sp. 1
- Limnodrilus sp.
- Branchiura sowerbyi
- Lumbriculidae g. sp.
- Non-clitellate megadriline

LEECHES
- Erpobdella punctata
- Helobdella stagnalis
- Glossiphonia complanata
- Placobdella parasitica
- Placobdella montifera

SNAILS
- Pleurocera acuta
- Amnicola cf. limosa
- Amnicola cf. binneyana
- Physa heterostropha
- Ferrissia fusca
- Gyraulus sp.
- Menetus sp.
- Helisoma anceps
- Lymnaea humilis

CLAMS
- Pisidium sp.
- Proptera alata
- Lampsilis siliquoidea
- Lampsilis ovata ventricosa
- Amblema rariplicata
- Fusconaia undulata wagneri
- Anodonta corpulenta

AMPHIPODS (Side-swimmers or scuds)
- Hyalella azteca
- Gammarus cf. fasciatus
- Gammarus cf. trogophilus
- Crangonyx sp.

ISOPODS (Pill bugs)
- Asellus militaris

CRAYFISH
- Orconectes cf. virilis

MAYFLIES
- Stenonema sp. 1
- Stenonema sp. 2
- Caenis sp.
- Ephemerella sp. 1
- Ephemerella sp. 2
- cf. Leptohyphes sp. 1
- Baetisca sp. 1
- Siphlonurus sp. 1

STONEFLIES
- Isoperla sp. 1
- cf. Atoperla sp. 1
- Perlesta sp. 1
- cf. Nehalennia sp. 1

DRAGONFLIES
- Libellula sp. 1

DAMSELFLIES
- Ischnura sp. 1
- nr. Hyponeura sp. 1

Table 13. Macroinvertebrate Animals (NSP, 1971) (Continued)

WATER BUGS
- *Ischnura* sp. 1
- *Plea striola*
- cf. *Belostoma* sp. 1

CADDISFLIES
- *Athripsodes* sp. 1
- *Athripsodes* sp. 2
- *Athripsodes* sp. 3
- *Athripsodes* sp. 5
- *Macronemum* sp. 1
- cf. *Agraylea* sp. 1
- *Polycentropus* sp. 1

ADULT BEETLES
- *Haliplus* sp. 3
- *Eretes* sp. 1
- *Gyrinus* sp. 1
- *Dineutus* sp. 1
- *Enochrus* sp. 1
- *Stenelmis* sp. 1
- *Stenelmis* sp. 2
- *Stenelmis* sp. 3
- cf. *Laccodytea* sp. 1
- cf. *Laccodytes* sp. 2
- Hydroporinae g. sp. 1
- Hydroporinae g. sp. 2
- Hydrophilidae g. sp. 2
- Hydrophilidae g. sp. 3
- cf. Hydrophilidae g. sp. 4

LARVAL BEETLES
- Dytiscidae g. sp. 1
- *Berosus* sp. 1
- Gyrinidae g. sp. 1
- Elmidae g. sp. 1
- Elmidae g. sp. 3
- Elmidae g. sp. 6

HORSEFLIES
- *Tabanus* sp. 1

BITING MIDGES
- *Palpomyia* sp. 1

OTHER FLIES
- *Limnophora* cf. *aequifrons*
- nr. Blephariceridae g. sp 1

MIDGES
- *Conchapelopia* sp. 1
- *Ablabesmyia janta*
- *Ablabesmyia ornata*
- *Ablabesmyia mallochi*
- *Cricotopus trifasciatus*
- *Cricotopus fugax*
- *Cricotopus bicinctus*
- *Cricotopus* sp. 1
- *Nanocladius* sp. 1
- *Orthocladius* sp. 1
- *Metriocnemus* sp. 1
- *Thienemanniella* sp. 1
- *Corynoneura* sp. 1
- Orthocladiinae g. sp. 1
- Orthocladiinae g. sp. 2
- *Glyptotendipes lobiferus*
- *Dicrotendipes* nr. *neomodestus*
- *Dicrotendipes* sp. 1
- *Polypedilum illinoense*
- *Polypedilum fallax*
- *Polypedilum halterale*
- *Cryptochironomus blarina*
- *Parachironomus* sp. 1
- *Parachironomus hirtalatus*
- *Parachironomous* nr. *pectinatellae*
- *Stictochironomus* nr. *devinctus*
- *Endochironomus* sp. 1
- *Tribelos* sp. 1
- *Xenochironomus* sp. 1
- Chironomini g. sp. 1
- *Cladotanytarsus* sp. 1
- *Tanytarsus* sp. 1
- *Rheotanytarsus* sp. 1

Table 14. Fish in Lake St. Croix, From Commercial Fishing and MN DNR Field Data (Krosch, 1972)

Common Name*	Scientific Name*	Common Name*	Scientific Name*
Silver lamprey	Ichthyomyzon unicuspis	Northern pike	Esox lucius
American brook lamprey	Lampetra lamottei	Muskellunge	Esox masquinongy
Paddlefish	Polyodon spathula	American eel	Anguilla rostrata
Lake sturgeon	Acipenser fulvescens	Trout-perch	Percopsis omiscomaycus
Shortnose gar	Lepisosteus platostomus	White bass	Morone chrysops
Longnose gar	Lepisosteus osseus	Yellow perch	Perca flavescens
Bowfin	Amia calva	Sauger	Stizostedion canadense
Mooneye	Hiodon tergisus	Walleye	Stizostedion vitreum vitreum
Goldeye	Hiodon alosoides	River darter	Percina shumardi
Gizzard shad	Dorosoma cepedianum	Logperch	Percina caprodes
Lake whitefish	Coregonus clupeaformis	Western sand darter	Ammocrypta clara
Brown trout	Salmo trutta	Johnny darter	Etheostoma nigrum
Brook trout	Salvelinus fontinalis	Iowa darter	Etheostoma exile
Bigmouth buffalo	Ictiobus cyprinellus	Smallmouth bass	Micropterus dolomieui
Smallmouth buffalo	Ictiobus bubalus	Largemouth bass	Micropterus salmoides
Quillback	Carpiodes cyprinus	Hybrid sunfish	Lepomis cyanellus x Lepomis gibbosus
Plains carpsucker	Carpiodes forbesi		
River carpsucker	Carpiodes carpio	Hybrid sunfish	Lepomis gibbosus x Lepomis macrochirus
Highfin carpsucker	Carpiodes velifer		
White sucker	Catostomus commersoni	Green sunfish	Lepomis cyanellus
Spotted sucker	Minytrema melanops	Pumpkinseed	Lepomis gibbosus
Golden redhorse	Moxostoma erythrurum	Bluegill	Lepomis macrochirus
Silver redhorse	Moxostoma anisurum	Rock bass	Ambloplites rupestris
Northern redhorse	Moxostoma macrolepidotum	White crappie	Pomoxis annularis
River redhorse	Moxostoma carinatum	Black crappie	Pomoxis nigromaculatus
Carp	Cyprinus carpio	Brook silverside	Labidesthes sicculus
Silver chub	Hybopsis storeriana	Freshwater drum	Aplodinotus grunniens
Golden shiner	Notemigonus crysoleucas	Burbot	Lota lota
Emerald shiner	Notropis atherinoides		
Spottail shiner	Notropis hudsonius		
Blacknose shiner	Notropis heterolepis		
Channel catfish	Ictalurus punctatus		
Black bullhead	Ictalurus melas		
Brown bullhead	Ictalurus nebulosus		
Yellow bullhead	Ictalurus natalis		
Flathead catfish	Pylodictis olivaris		

Supplemental List - Species not captured but known to exist in Lake St. Croix

Common Name*	Scientific Name*
Blue sucker	Cycleptus elongatus
Northern hog sucker	Hypentelium nigricans
Stonecat	Noturus flavus

* Common and scientific names according to Accepted Common and Scientific Names in American Fisheries Society's Special Publication No. 6 (1970)

Table 15. Estimated Sport Catch in Numbers and Pounds of Fish, and Pounds of Fish Per Acre in Lake St. Croix During Three Fishing Seasons (Krosch, 1970)

SPECIES	1966-67 Number of fish	1966-67 Pounds of fish	1966-67 Pounds per acre	1967-68 Number of fish	1967-68 Pounds of fish	1967-68 Pounds per acre	1968-69 No. of fish	1968-69 Lbs. of fish	1968-69 Lbs. per acre
Northern pike	193	926	0.11	292	1,402	0.17	169	811	0.10
Walleye	4,774	7,066	0.86	5,365	7,940	0.97	8,103	11,992	1.46
Sauger	6,453	4,690	0.56	8,180	5,972	0.73	12,830	9,366	1.14
Crappie spp.	14,323	8,880	1.08	7,411	4,597	0.56	3,590	2,226	0.27
White bass	17,340	18,727	2.28	9,142	9,874	1.20	26,343	28,450	3.47
Smallmouth & Largemouth bass	966	927	0.11	546	524	0.06	1,155	1,109	0.13
Channel catfish	431	1,017	0.11	504	1,190	0.14	2,234	5,273	0.64
Suckers & redhorse	318	445	0.05	68	95	0.01	287	402	0.05
Drum	1,518	1,397	0.17	904	833	0.10	3,848	3,540	0.43
Carp	752	1,805	0.22	311	747	0.09	1,369	3,285	0.40
Total	47,068	45,880	5.57	32,723	33,174	4.04	59,928	66,471	8.09

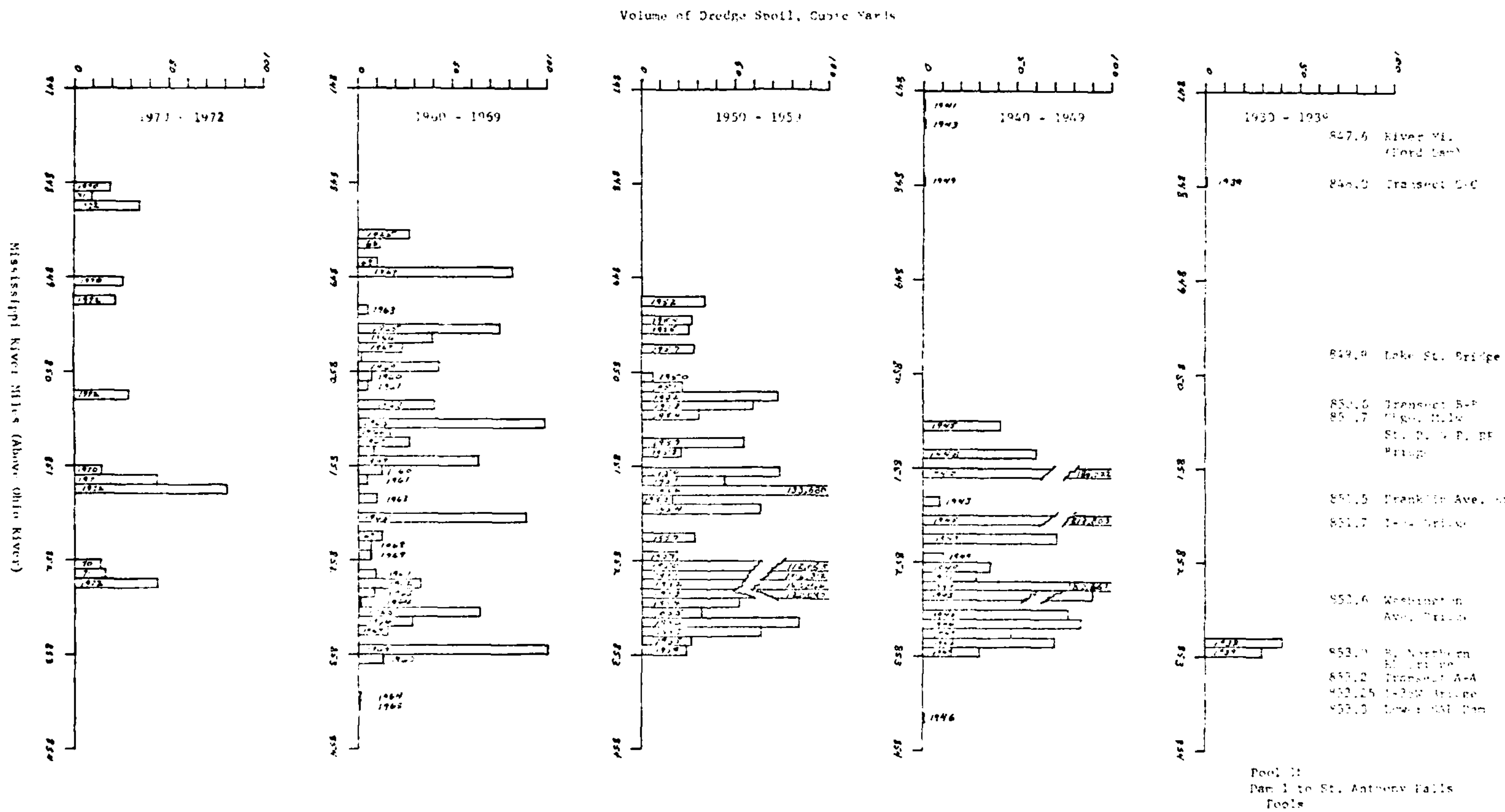

Figure 1. Annual Volume of Sediment Dredged Within Each River Mile of the Minnesota River, Arranged by Decade (S.P.D.-NCS, 1973).

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10. APPENDIX B: ARCHAEOLOGICAL BACKGROUND INFORMATION

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Appendix 2

National Register of Historic Places

Archaeological and Historic Sites in Minnesota in the Study Area along the Mississippi, Minnesota, and St. Croix Rivers Which are Now Listed in the National Register of Historic Places

Sites Designated as Historic and Worthy of Preservation, Not yet Included in the National Register, in Minnesota Which are Adjacent to the Minnesota, Mississippi, and St. Croix Rivers

10. APPENDIX B: ARCHAEOLOGICAL BACKGROUND INFORMATION

Archaeological and historic sites of importance consist of such diverse elements as prehistoric village sites, petroglyphs (rock pictures), burial mounds, log cabins, forts, and so forth. Sites of significance may date from thousands of years ago to very recent times. Interest in studying elements of human history also varies as much with the times as interest in studying elements of natural history.

STUDIES IN THE LATE 1800's: THE LEWIS AND HILL SURVEY

Fortunately for our study now there was a strong interest in the late 19th Century in burial mounds; a massive study was pursued for approximately 20 years by Alfred J. Hill and Theodore H. Lewis. The extent of their work is best understood by examining a few of their manuscripts, a few samples of which are reproduced in this report. In 1928, Charles R. Keyes wrote of their accomplishments:

> "The great extent of the archaeological survey work accomplished by Lewis and Hill cannot be appreciated except through an extended examination of the large mass of manuscript material that has been preserved. This consists approximately of the following forty leather-bound field notebooks well filled with the original entries of the survey; about a hundred plats of mound groups drawn on a scale of one foot to two thousand; about eight hundred plats of effigy mounds (animal-shaped mounds from Minnesota, Wisconsin, Iowa, and Illinois) on a scale of one foot to two hundred; about fifty plats of "forts" (largely village sites of the Mandan type) and other inclosures on a scale of one foot to four hundred; about a hundred large, folded tissue-paper sheets of original, full-size petroglyph rubbings with from one to six or more petroglyphs on each; about a thousand personal letters of Lewis to Hill; four bound "Mound Record" books made by Hill and in his handwriting; eight large, well filled scapbooks of clippings on archaeological matters made by Lewis; numerous account books, vouchers, and other miscellany...
>
> "A single sheet of summary found among the miscellaneous papers of the survey, apparently made by Lewis, is eloquent in its significance. Tabulated by years and place of entry the mounds alone

that were actually surveyed reach a grand total of over thirteen thousand -- to be exact, 855 effigy mounds and 12,232 round mounds and linears...

"The survey is quite full for Minnesota, where work was done in all but three counties of the state, resulting in records of 7,773 mounds, besides a number of inclosures... much information was also gathered from the river counties of Nebraska, Iowa, Kansas, and Missouri. In Wisconsin the survey touched more than two-thirds of all the counties, mostly in the field of the effigy mounds in the southern half of the state, where the records supply detail for no less than 748 effigies and 2,837 other mounds. Iowa was explored most fully in the northeastern counties as far south as Dubuque, yielding data on 61 effigy mounds, 553 other mounds, and several inclosures. ...the survey yielded its richest results in Minnesota, the eastern parts of the Dakotas, northeastern Iowa, and the southern half of Wisconsin..." [Surveys were also conducted in the Dakotas, Manitoba, Missouri, Nebraska, Kansas, Illinois, Indiana, and Michigan -- in all, eighteen states.]

"The strength of the survey consists, first of all, in the dependability of Lewis as a gatherer of facts...he worked as a realist, measuring and recording what he saw with painstaking accuracy and unwearying devotion... And the fact that these surveys were made at a time when a large number of mound groups that have since disappeared, or all but disappeared, were still intact, gives the work of Lewis and Hill and incalculable worth... So far as Iowa is concerned, something like half of the antiquities of the northeastern part of the state are recoverable only from the manuscripts of the Northwestern Archaeological Survey..."

A typical description of the reporting format followed by Lewis and Hill is reproduced here:

[IN: MOUNDS IN DAKOTA, MINNESOTA AND WISCONSIN]

3. OTHER MOUNDS IN RAMSEY COUNTY, MINNESOTA

At the lower end of the Pig's Eye marsh already mentioned, there stood (April, 1868) an isolated mound, not situated on the bluffs, but below them, near their foot, at the highest part of the river bottom on the sloping ground half-way between the military road and the road-bed of the St. P. & C. R. R., then in course of construction, and distant about three hundred and fifty feet southward from the culvert on the former.

It was in a cultivated field, and had itself been plowed over for years; yet it still had a mean height of six and a half feet; its diameter was sixty-five feet. The top of it was only thirty-one feet above the highwater of the Mississippi, according to the levels taken by the railroad engineers. The location of the mound, according to U. S. surveys, was on the N 1/2 of SE 1/4 of Sec. 23, T. 28, R 22, and about one mile north of Red Rock landing. Mr. J. Ford, one of the old settlers of the neighborhood, said that a man named Odell had, some years previously, dug into it far enough to satisfy his curiosity, as the discovery of human bones clearly proved it to have been built for sepulchral purposes.

7. MOUNDS AT PRESCOTT, WISCONSIN.

At the angle formed by the confluence of the St. Croix and Mississippi Rivers, on the eastern bank of the former, is the town of Prescott, Wisconsin. On May 13, 1873, three hours' time was employed in making such reconnaissance survey as was feasible of the mounds which stretch along the bluff on the Mississippi there. The smallest of them was about twenty-five feet diameter and one foot high, and the largest fifty-six feet diameter and four feet high, as nearly as could be then ascertained.

Pictographs were common on caves along the Mississippi River bluffs. Lewis and Hill recorded their locations and frequently the pictures themselves. Although specific reference was made to them in Houston, Winona, Washington, and Ramsey counties in Minnesota and Alamakee and Clayton counties in Iowa, it would be unwise to assume that they were limited to these locations.

Captain Carver, in 1766-67 explored a cave (in present day Ramsey County) as being of "amazing depth and containing many Indian hieroglyphics appearing very ancient." The cave, called by the Dakota "Wakan-teebe", became a popular tourist attraction in the 1860's. Railroad construction was responsible for its destruction by the 1880's.

PRESENT CONSIDERATIONS

The difficulty, then, is not the absence of records of significant sites, but rather that records of thousands of sites exist. And although archaeologists have resurveyed some of the sites, vast areas have not been checked since the original surveys. The farmer, in the course of clearing and farming his land, is chiefly responsible for the destruction of the sites, and most of the sites have by now been destroyed.

MINNESOTA

This section contains information on significant archaeological and historic sites in Minnesota.

Background

This format evolved from problems encountered in developing an inventory of sites. The listing of reasons for not doing so which follows is included because it may shed some light on future problems also.

Original plans were made to provide an inventory of Minnesota archaeological sites which lie in the study area. This idea was abandoned, however, due to the following considerations:

1. The number of sites in close proximity to the river is large and the amount of work required to review existing records (beginning in the early 1800's) exceeds the value of such an inventory in this report;

2. The records are known to be incomplete in many cases, scanty for certain areas or incorrect so that reliability of the inventory is questionable;

3. Many sites once recorded have been destroyed by the action of others (not the Corps of Engineers) but the records have never been updated. Nor has there ever been a complete systematic inventory of archaeological sites in Minnesota.

4. In many cases the location of sites given is not sufficiently accurate to determine if the site is close enough to the river bank to be threatened. In some cases, where the bluffs are close to the river bed, a vertical elevation of many feet may effectively remove a site from any threats by water, dredge spoil, or construction. The records may not show this.

5. The Minnesota State Archaeologist is understandably reluctant to publish for public consumption a list or inventory of archaeological sites because of risk of robbery, despoliation, vandalism, or unauthorized unscientific excavation. Such cases have been known in the past. However, the State Archaeologist and his staff have expressed the willingness and desire to assist individuals or government bodies in locating and identifying sites for preservation or excavation before destruction.

Impact on Prehistoric Archaeological Sites

Because the files of the State Archaeologist are located in the Twin Cities, it was possible to engage a professional archaeologist to investigate the current status of those archaeological sites in the Mississippi, Minnesota and St. Croix River areas in Minnesota. The report by consultant Jan Streiff is reproduced here in its entirety.

A Report of the Impact of the U. S. Army Corps of Engineers on Prehistoric Archaeological Sites on the Lower Mississippi, Lower St. Croix, and Lower Minnesota Rivers in Minnesota

By Jan E. Streiff, Archaeologist, Department of Anthropology, University of Minnesota, Minneapolis.

Introduction. There are approximately eighty-five (85) designated sites in the Corps of Engineers area under consideration (i.e., the Mississippi River from St. Anthony Falls to the Minnesota-Iowa border, the Minnesota River from Shakopee to Pike Island, and the St. Croix from above Stillwater to Prescott). The information on these sites has been collected since the late 1800's and all the data are filed in the Archaeology Laboratory at the University.

Although some of these sites have been revisited since being recorded, and a few have even been excavated, most have not been rechecked. Consequently there are many unknown things about most of the sites listed in this report. Ideally, a crew should have been sent out to resurvey the river valleys in question, to determine if sites formerly recorded are still there and, if not, how they were destroyed -- particularly if by the Corps of Engineers.

Since such an on-site survey was impossible at this time, the written records will have to suffice. I have organized the known sites into the three categories shown below.

Classification of Sites.

Group I. These are sites definitely known to have been destroyed by Corps of Engineers' activities. There are nine (9) of these sites.

Group II. These are sites in the area under consideration which should not be affected by the Corps because they appear too high above the river channels. Although they may never be flooded by raised water levels, they should be kept in mind as possibly being destroyed by borrow activity, dredging, etc. There are six (6) of these sites.

Group III. This is the largest group of sites (73) within the Corps of Engineers' area. This is the group for which no definite classification can be given. There are many reasons:

a. our site location description is too vague to determine if the site is or was in danger.

b. sites which were destroyed, such as the mound groups at Dresbach, but where we cannot determine if the destruction was carried out by the Corps of Engineers dam construction or by some unrelated project.

c. sites, such as those on Pig's Eye Island, which have not been reexamined since recorded but are so located as to be assured destruction by a fluctuation in the river level or at least damaged by erosion by the river. Any dredging of the river and subsequent depositing of the debris on the nearby shore would undoubtedly cover the site.

<u>The Effect of Corps of Engineers' Activities on Archaeological Sites by Pool</u>. The following chart is a breakdown by pool of archaeological sites affected by the Corps of Engineers. The sites are listed using the groupings defined above.

Pool #	Group #1* (destroyed)	Group #2 (not affected)	Group #3* (uncertain)
2	2	1	7
3	4	2	11
4	0	1	7
5	1	0	1
5 or 5A	2	0	3
6	0	0	1
7	0	0	7
8	0	0	6
St. Croix River	0	0	5
Minnesota River	0	2	25
	9	6	73

*For a detailed description of the sites destroyed by the Corps of Engineers projects, see Appendix 1. A description of the Group III sites is included in Appendix 2.

<u>Conclusions</u>. Although this report is rather inadequate to determine the <u>real</u> impact of the Corps of Engineers on archaeological sites (there are still those 73 sites for which we have no information on Corps of Engineers' impact), it does point up the great need for future surveys along Minnesota's three greatest rivers to determine what effect the Corps of Engineers will have on prehistoric sites.

The importance of these rivers to life was no less important to the original Americans than it is to us today. And it is vital to the history of the American Indian that an attempt be made, if not to preserve, then at least to record the habitation and burial areas that are so numerous along these waterways.

The Corps of Engineers can expect that the professional archaeologists in Minnesota will do everything possible to cooperate with them to see that these ends are achieved.

February 1973

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A description of the archaeological sites affected by the Corps of Engineers activities on Lake St. Croix follows:

Group I.

Sites destroyed	None

Group II.

Sites not affected.	None

Group III.

Uncertain as to effect on sites-- potentially destroyable.	WA 22 T 30 R20
	WA 12 T 30 R20
	WA 10 T 28 R20

WA = Washington County
T = Township
R = Range

Note: For the exact locations (sections, quarter sections, etc.) of the above sites, contact: Jan E. Streiff
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National Register of Historic Places

Archaeological and Historic Sites in Minnesota in the Study Area along the Mississippi, Minnesota, and St. Croix Rivers Which Are Now Listed in the National Register of Historic Places

In 1966, the National Historic Preservation Act was passed. It provides for comprehensive indexing of the properties in the nation which are significant in American history, architecture, archaeology, and modern culture. The Register is an official statement of properties which merit preservation. Listed in the latest (1972) edition of the National Register of Historic Places are the following sites adjacent to the Mississippi, Minnesota, and St. Croix Rivers in Minnesota. These sites have not been destroyed or damaged extensively by previous Corps of Engineers' activity, but must be considered as possibly vulnerable in the future:

St. Croix Boom Site-located three miles north of Stillwater on the St. Croix River in Washington County. From 1840 to 1914 this was the terminal point for the white pine lumber industry. Here millions of logs were sorted, measured, and rafted to downstream sawmills. The boom site died naturally as a result of the depletion of timber late in the 19th Century. There are no remains of the log boom, but the general setting is unimpaired.

Marine Mill Site-located in Washington County at Marine-on-St. Croix. It is the site of Minnesota's first commercial saw mill which was founded in 1839. At present only the ruins of the engine house and a marker specify the site.

Glossary

acre-foot - the quantity of water required to cover an acre to a depth of 1 foot. It is equivalent to 43,560 cubic feet.

alluvial material - sediment, usually sand or silt, deposited on land by flowing water.

aerobic - an environment in which free oxygen is present.

anaerobic - an environment in which free oxygen is lacking.

aquifer - a water-bearing layer of porous rock, sand, or gravel.

backwaters - a term often divided now into sloughs and lakes and ponds adjoining a river.

benthic - pertaining to the bottom of a body of water.

benthic invertebrates - animals lacking a spinal column living in the benthic zone.

BSFW - Bureau of Sport Fisheries and Wildlife (U. S. Department of the Interior).

channel - a natural or artificial watercourse with definite bed and banks which confine and conduct flowing water.

cfs - cubic feet per second, used as a measure of rate of water flow in a river.

chute - sloping channel or passage through which water may pass.

closing dam - low dam extending across a side channel. These were constructed to divert water from side channels to the main channel during low water periods to maintain water sufficient for navigation.

coulee - steep-sided tributary valleys, commonly used in Wisconsin.

deciduous forest - forest dominated by broad-leaved trees which lose their leaves each autumn.

discharge (rate of flow) - the quantity of water passing a point in a stream channel per unit of time, normally measured in cubic feet per second (cfs).

drainage area - the land area drained by a stream above a specified location on the stream. Measured in a horizontal plane, it is so enclosed by higher land (a divide) that direct surface runoff from precipitation normally drains by gravity into the stream above that point.

drawdown - a process of lowering the water level of an impoundment.

Driftless Area - the portion of southwestern Wisconsin, southeastern Minnesota, northeastern Iowa and northwestern Illinois which was virtually untouched by the last advance of the Pleistocene glaciers (i.e., Wisconsin Glacier). It is thought by many that it was never glaciated.

flood - a temporary rise in streamflow and water level (stage) that results in significant adverse effects in the vicinity under study.

flood peak - the highest value of water level or streamflow attained by a flood.

floodplain - the relatively flat lowland adjoining a watercourse or other body of water subject to overflow therefrom.

FTU - Formazine Turbidity Units - arbitrarily defined units used as standard for measuring water turbidity, currently recommended by APHA, et al., 1971.

gaging station - a site on a stream, canal, lake or reservoir where systematic observations of water-surface elevation or streamflow (discharge) are obtained.

humus - the surface layer of soil combining partially decomposed organic matter and mineral particles.

JTU - Jackson Turbidity Unit - arbitrarily defined units used as a standard for measuring water turbidity.

lake and pond - open areas with little or no current. They are formed behind dams, or on mature floodplains as a result of first scour, then abandonment, by the lowered river.

littoral - the shore zone of a body of water.

macroinvertebrates - collectively, all invertebrate organisms visible with the unaided eye.

main channel - the portion of the river used for navigation by large commercial craft. A minimum depth of 9 feet and a minimum width of 200 - 400 feet were established by the lock and dam system and are maintained by periodic dredging.

main channel border - the water zone between the main channel boundary and the main river bank, islands, or now submerged channel boundaries. Wing dams are located in this zone.

mesic - a type of vegetation which develops under moderate moisture conditions.

moraine - an accumulation of earth and stones carried and finally deposited by a glacier.

MPN/1 - most probable number per liter - an estimate of bacterial abundance (See Methods, Appendix A1).

MRRC - Mississippi River Research Consortium

MRRPC - Mississippi River Regional Planning Commission

mussels - clams, bivalves of the Phylum Mollusca.

outwash - glacial till reworked and sorted into sand and gravel, etc., by meltwater.

pedalfer soils - well-leached soils; soils that lack a more or less hardened layer of accumulated carbonates.

pedocal soils - soils that develop under approximately equal precipitation and evaporation conditions; soils that contain a definite more or less hardened layer of accumulated carbonates.

physiography - a branch of science that deals with the physical features of the earth.

phytoplankton - collectively, all those plants suspended in and on the surface of the water, usually microscopic.

piezometric surface - surface to which water of a given water-bearing rock unit will rise under its own pressure balance; an artesian water table.

plankton - free-floating plants and animals drifting in the water, usually microscopic.

podzolic - light-colored acid soil developing under coniferous forests, in cool, humid regions; result of leaching and removal of soluble minerals from the top layer into the deep layers.

riprap - rock fortifications on banks or shores which protect them from erosion by dissipating the energy of waves and wakes.

River Mile - miles above the entrance of the Ohio River at Cairo, Illinois measured on the river.

river stage - the elevation of a particular river surface.

roller gates - movable gates of dam; horizontal cylinders on inclined tracks which can be adjusted to affect water flow and its level.

rookery - the nests and breeding place of a colony of birds; the colony of birds.

runoff in inches (in.) - the depth to which the drainage area would be covered if all the runoff for a given time period were uniformly distributed on it.

savanna - grassland with trees spaced so far apart that their crowns are separate and the grass receives direct sunlight.

side channel - departures from the main channel or main channel border. At normal river stage, a current occurs in these channels.

slough - body of water through which there is no current at normal river stage. Muck bottoms and an abundance of submergent and emergent vegetation are characteristic. The slough category lies somewhere between the side channel and lake and pond categories.

spoil - waste material removed in making an excavation.

streamflow, discharge - the volume of water passing a point, per unit time, measured in cfs or in cubic meters per second.

tailwaters - water areas immediately below the dams. They are affected by the movement of water through the gates and locks, and they change in size in response to changing water levels.

tainter gate - movable gate of a dam which is a horizontal cylinder segment mounted on a steel framework attached to a horizontal downstream rod so it may be adjusted up and down to affect water flow and its level.

thermocline - a layer in an incompletely-mixed body of water where the temperature during the summer drops rapidly (more than 1°C. per meter) as the thermometer is lowered.

till - unsorted rock, sand and gravel deposited by the melting of glacier ice.

UMRCBS - Upper Mississippi River Comprehensive Basin Study.

UMRCC - Upper Mississippi River Conservation Committee.

watershed - drainage basin or drainage area.

weathering - the geologic process of decomposing rocks by the action of the forces of weather.

wing dams - low structures extending radially from shore into the river for varying distances to constrict low water flows. They were constructed of rocks and brush mattresses to establish a deeper main channel.

zooplanktonic - pertaining to the animal life of plankton.

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